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THE NORTH CAROLINA GEOLOGICAL SURVEY

JOSEPH HYDE PRATT, STATE GEOLOGIST.

BULLETIN No. 14

145
434

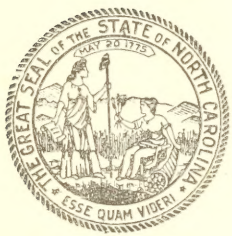
THE NATURAL HISTORY AND CULTIVATION OF THE DIAMOND-BACK TERRAPIN

WITH NOTES ON

OTHER FORMS OF TURTLES,

BY

R. E. COKER, PH. D.



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LETTER OF TRANSMITTAL.

RALEIGH, N. C., July 1, 1906.

To His Excellency, HON. ROBERT B. GLENN,

Governor of North Carolina.

SIR:—On account of the rapid decrease in the quantity of the diamond-back terrapin in eastern North Carolina waters, a report has been prepared by Dr. R. E. Coker on the habits, economic value, and cultivation of the diamond-back terrapin, with suggestions regarding the prevention of its extermination. This report is submitted for publication as Bulletin No. 14, entitled The Natural History and Cultivation of the Diamond-back Terrapin.

Yours obediently,

JOSEPH HYDE PRATT,

State Geologist.

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PREFACE.

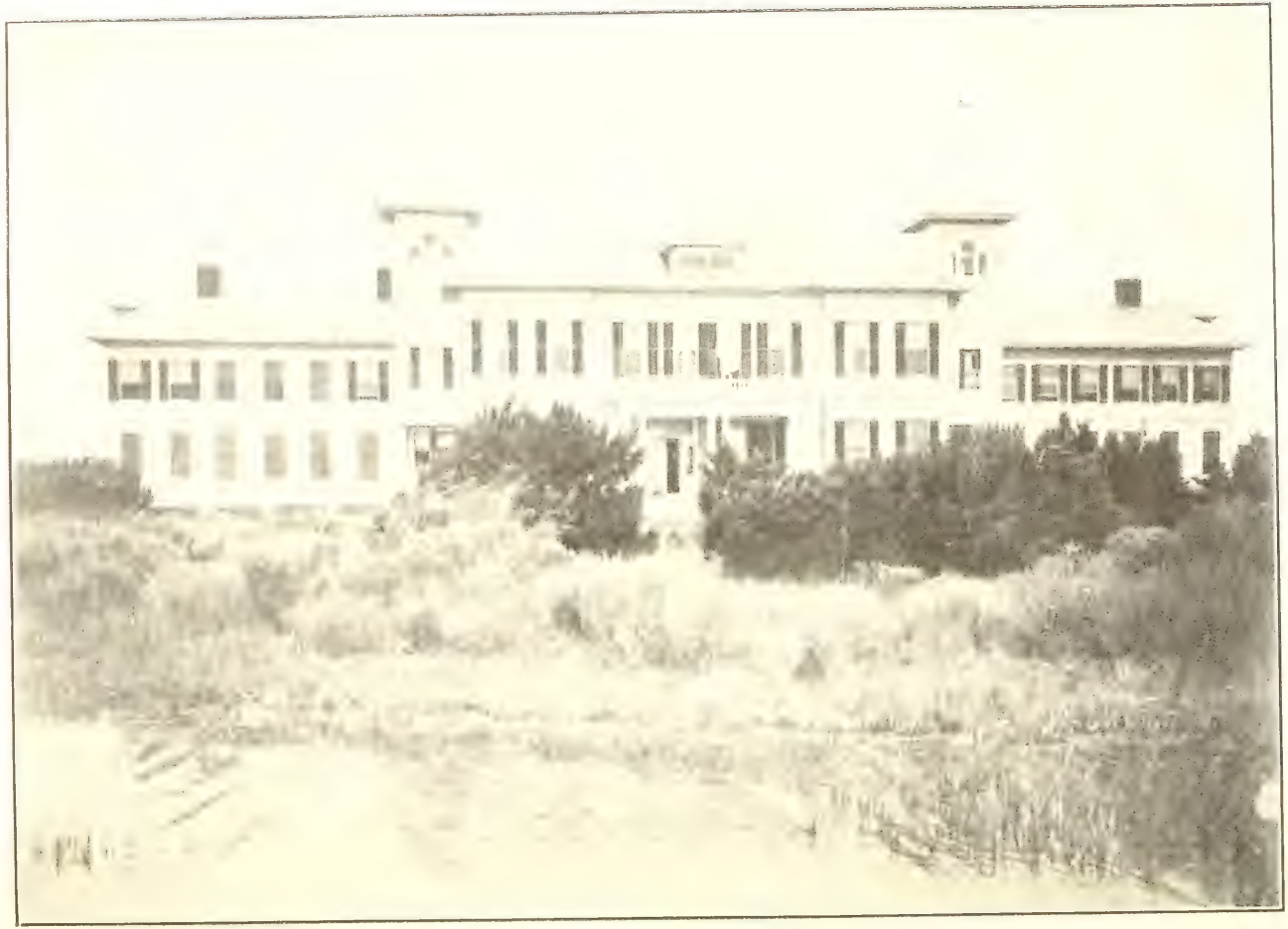
The rapid exhaustion of a valuable fishery through the extinction of the highest-priced food product of North Carolina waters led the North Carolina Geologic and Economic Survey, in coöperation with the United States Bureau of Fisheries, to undertake an investigation regarding the habits and life-history of the diamond-back terrapin and the condition of the terrapin industry in North Carolina. This investigation was begun in July, 1902, in connection with other experimental work carried on at the Beaufort Laboratory by Dr. R. E. Coker, the Biologist of the North Carolina Geologic and Economic Survey, when he was temporary scientific assistant at the Laboratory. During the following winter and summer the observations on terrapins were continued in connection with other studies. Visits were made to the terrapin pounds near Charleston, S. C., in 1902, and to pounds at Crisfield, Md., in 1903. The experimental pound at Beaufort was discontinued in 1903 on account of the Bureau of Fisheries having established a larger one at Lloyds, Md. Chapters II and IV embody the results of the experimental work made during the years 1902 and 1903 at Beaufort, N. C., together with a few additional notes collected at other times.

There is given in Chapter V a brief description of the work done at Lloyds, Md., by Professor W. P. Hay of Washington, D. C. Chapter VI takes up the Cultivation of the Snapping-Turtle or Soft-shell Tortoise, *"Suppon,"* in Japan, as described by Dr. K. Mitsukuri, and is reprinted from the report of the Bureau of Fisheries. On account of considerable similarity in the cultivation of this snapping-turtle and the diamond-back terrapin, it has been thought advisable to reprint this chapter here as being of interest and value to those who are interested in the diamond-back terrapin. A few additional notes on the sea turtles, which are given in Chapter VII, are the results of Dr. Coker's work during the summer of 1905.

Special acknowledgments are due to: Dr. Caswell Grave, Director of the Laboratory at Beaufort, for valuable suggestions at the beginning of this investigation and for many courtesies extended

at all times during the work; Mr. Charles Hatsel of the Laboratory for the efficient assistance that he has rendered and for his care of the terrapins in the pounds, which were under his supervision a great deal of the time; Mr. J. H. Potter of Beaufort, N. C.; and to many other dealers and fishermen for their encouraging assistance.

Joseph Hyde Pratt.
State Geologist.



LABORATORY OF THE U. S. BUREAU OF FISHERIES AT BEAUFORT, N. C.

THE CULTIVATION OF THE DIAMOND-BACK TERRAPIN.

By R. E. COKER.

CHAPTER I.

THE DIAMOND-BACK TERRAPIN.

INTRODUCTION.

At the beginning of the investigation of the cultivation of the diamond-back terrapin in North Carolina, several practical and important questions regarding the terrapin suggested themselves as follows:

1. Is present legislation for the protection of this form based on a satisfactory knowledge of the habits of the terrapin?

2. Can anything further be done by either the State or National Government towards checking the extermination of the terrapin?

3. Is it practicable to breed and grow the terrapin as a private enterprise, as the Japanese do so successfully with their soft-shell Snapping-Turtle, *Trionyx japonicus*, Schlegel?*

Before these questions can be satisfactorily answered information must be had on many points, as:

a. Habits of adults, feeding, breeding, etc.;

b. Habits of young, food, enemies, chances for living;

c. Rate of growth, age of market sizes, and age at which breeding begins.

Adequate data has not yet been secured on all these points, but in the following pages the results of the work accomplished and information collected is given.

DESCRIPTION AND DISTRIBUTION.

The diamond-back terrapin occurs along the Atlantic and Gulf coasts of the United States from Buzzard's Bay, Mass., south and

* *Mitsukuri, K.* "The Cultivation of Marine and Fresh-water Animals in Japan." Bulletin Bureau of Fisheries for 1904, Vol. XXIV, pp. 257–289. See also, Chapter VI of this report.

west to Texas; and belongs to J. E. Gray's genus *Malaclemmys*. They have in recent years all been included in the one species, *Malaclemmys centrata* (Latreille); but W. P. Hay, after comparison of specimens from many regions, has shown in a recent paper* that we have to do with more than one species. The several species and the distribution of each as determined by him are as follows:

Malaclemmys centrata (Latreille). The Carolina Terrapin. From the neighborhood of Cape Hatteras southward to the coast of Florida.

The subspecies, *M. centrata concentrica* (Shaw). The Chesapeake Terrapin. From Buzzard's Bay, Massachusetts, to Virginia or North Carolina; Long Island Sound, Delaware and Chesapeake Bays, etc. (See Pl. II, A and B).

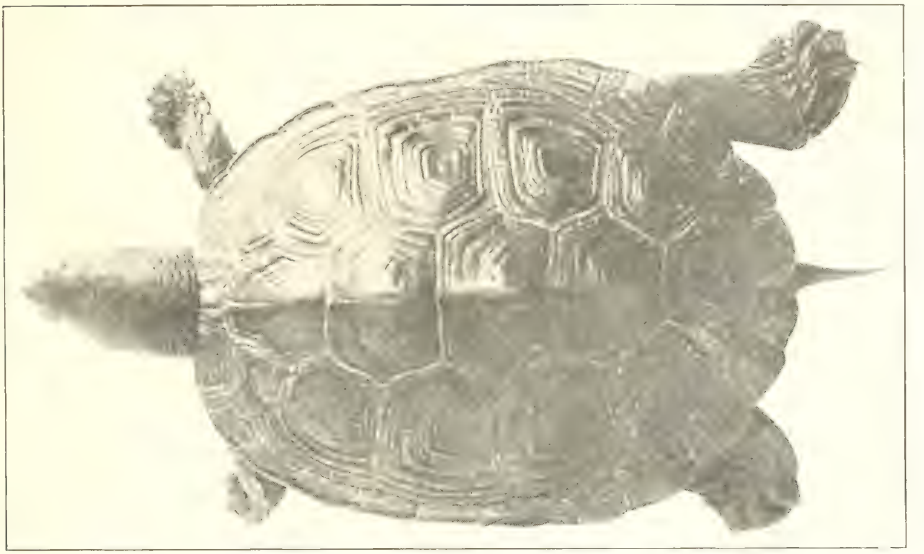
M. macrospilota (Hay). The Florida Terrapin. Western Coast of Florida.

M. Pileata (Maximilian zu Wied). The Louisiana Terrapin. So far as is known, the range of this terrapin is along the Gulf coast from the region about the mouth of the Mississippi River eastward as far as Mobile Bay, and possibly well along the coast of Florida.

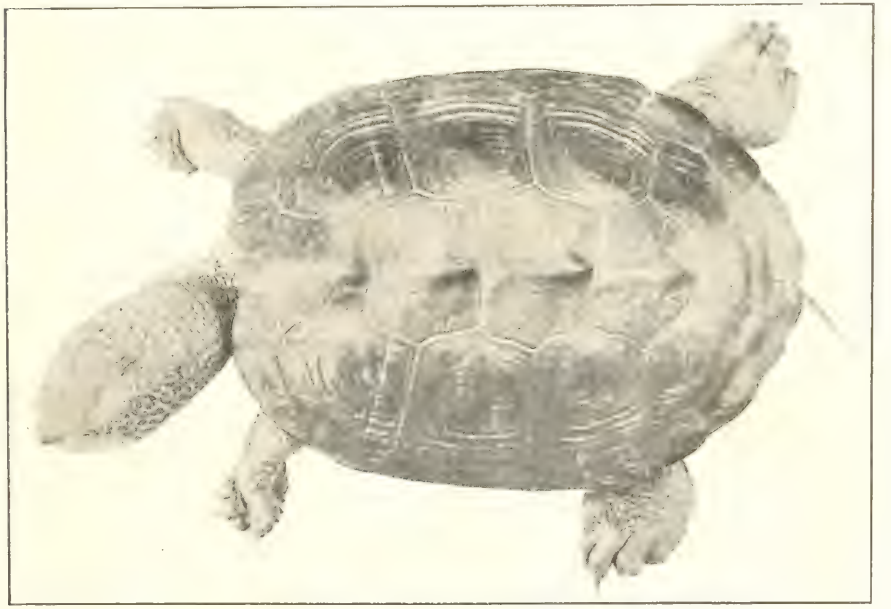
M. littoralis (Hay). Coast of Texas and outlying islands.

Both *M. centrata* and its subspecies, *M. centrata concentrica*—the "Carolina" and the "Chesapeake" terrapins, respectively—occur in North Carolina, but in varying proportions in different localities. Unfortunately, the differences between the two types are not susceptible of such accurate statement that one can always distinguish the two forms. The existence of two or more types seems to be generally accepted by terrapin dealers and others familiar with terrapins. The diagnostic characters, however, are based on points in which terrapins are very variable, so that it is difficult to identify a given individual unless it is a good type of the species or of the subspecies. This difficulty is, doubtless, particularly noticeable in this State, the geographic meeting-place of the two forms. It is the belief of the writer that many "Chesapeake" terrapins will be found in the counties of Dare and Hyde, though the writer has not, since the appearance of Hay's paper, had opportunity to examine considerable numbers from that region. The terrapin shown in A, Pl. II, is a good representative of the Chesapeake type, and was taken near Stumpy Point in Dare County. About Beaufort, the "Southern" form predomi-

* "A Revision of *Malaclemmys*, a Genus of Turtles," William Perry Hay, Bulletin of Bureau of Fisheries for 1904, Vol. XXIV, pp. 1 to 20, Plates I to XII.



B, ADULT FEMALE, CHESAPEAKE TYPE, FROM DARE COUNTY.



A, DIAMOND-BACK TERRAPIN ADULT (FEMALE), CAROLINA TYPE, 6½ INCHES LENGTH OF PLASTRON; TOP SHELL 7 INCHES. X ½ (CIR.).

nates. An expert terrapin dealer of the Baltimore market states that he sometimes receives from Wilmington, N. C., terrapins that cannot be distinguished from "Chesapeakes," either in appearance or flavor.

Plate II, A, shows a 6½-inch female of the "Carolina" or "Southern" type. Perhaps the most constant and convenient diagnostic characters are the size and shape of the head (larger and with blunter snout in the "Carolina") and the outline of the carapace (parallel-sided in the "Carolina," and flaring posteriorly in the "Chesapeake"), A and B of Pl. II. Yet in these, as in all other points, terrapins from any region are very variable. Terrapin dealers usually attach a higher value to the "Chesapeake" market type than to the "Southern," although terrapins have been seen with heads larger, in proportion, than that of the terrapin of A, Pl. II, yet pronounced by an experienced terrapin dealer of the Baltimore market good "Chesapeakes."

Terrapins do not usually attain to as large a size in North Carolina as in the Chesapeake, and 7-inch and 8-inch terrapins are rare in Carolina.

CHAPTER II.

OBSERVATIONS ON TERRAPINS IN NATURE.

HABITS OF LIFE AND METHODS OF COLLECTING.

The diamond-back terrapin is an inhabitant of the salt and brackish marshes which occur in regions such as Beaufort Harbor, where the density of the water ranges from 1.015 to 1.023, or along the shores of Pamlico Sound, where the average density is much lower, as at Judiths Island, Pains Bay, etc. The writer has not learned of its occurrence in North Carolina rivers above the region of brackish water. Doubtless the distribution of its natural food supply is an important factor in the restricting of its habitat to salt and brackish water, for terrapins seem by no means dependent on salt water. Terrapins kept for several years in pens at the Laboratory supplied only with fresh water have not seemed to suffer for the want of salt water. In this case, however, they were fed with salt-water fish, crabs, etc.

In Beaufort Harbor, though the terrapins are rare, their local distribution is general. They live in the extensive marshes of Newport River, north and west of the Laboratory, Pl. IV, A; on the Town marsh, in Gallants Creek; in the Middle marshes, north of Shackleford Channel; and in the marshes of North River. The Outward marshes in North River, 2 to 3 miles above Lenoxville, is one of the best places to hunt them.

In tide regions they are found at low tide nearly or entirely buried in the mud or hidden under drift, but are occasionally seen crawling about. At high tide they swim about over the marshes in search of food. Their habits in the waters of North Carolina, that are practically tideless, have not been observed.

Some idea of the habits of the terrapin may be gained from a description of a typical collecting trip. While the tide is still ebbing, the collector starts out over the marshes carrying a stick with which to probe into the mud. The borders of the open places in the marsh are searched with especial care, since the terrapins are supposed to frequent these places for convenience in feeding at high tide. It requires the sharp eye of an experienced fisherman to detect the presence of a terrapin when all except, perhaps, the head and possibly a

small part of the carapace is buried in the soft black mud of the grassy marsh. Often they are found merely by probing with the stick into suspicious depressions in the mud, or other places, which appear probable or possible hiding-places of a terrapin. On one occasion a terrapin just found in the marsh was put back on the ground and allowed to crawl away. After a few minutes the path over the mud was traced. Winding about through the grass for a few yards, it passed through several watery depressions and terminated at one just large enough to accommodate a crab that was the only apparent creature in it. Only the evidence of the fresh track terminating there led to further examination. The terrapin was found buried 2 or 3 inches in the soft mud underneath the crab.

At high tide, when the water is over the marshes and the terrapins are swimming about and feeding, another method of collecting is followed. Ballast is put in the stern of a boat, while the fisherman stands in the bow, and, poling his boat carefully, skirts along the border of the grassy areas. The terrapins are found swimming near the surface and nibbling at the marsh grass, feeding probably, as stomach examinations indicate, on the small snails which occur so abundantly on this grass. A dip-net (an ordinary crab-net) is used as the instrument of capture.

Formerly the drag-net was sometimes used at Beaufort for terrapins. Commonly the net would be set across the lower part of the marsh "creek," while the fishermen would go up to gouge the bottom and stir and beat the water. The terrapins thus routed out would go down with the tide and get in the "bunt" (slack) of the net. The lead-line was then rapidly taken up and the terrapins were thus securely imprisoned. Except on a very smooth and firm bottom, the method of "footing up," commonly used for fish, would not be successful with terrapins.

In other regions, as in Pamlico Sound, the drag-net is used in a different manner. While the "canoe" (dug-out) or skiff is quietly poled along a short distance from the marsh, the surface of the water is carefully scanned; and when the head of a terrapin is seen, the net is quickly put over and hauled up to the shore.

All the methods of fishery mentioned above, however, are practically obsolete about Beaufort. Most of the terrapins brought to market are found accidentally by fishermen seeking for fish or shell-fish. Thus, an oysterman, working in clear and shallow water in winter,

and seeing the outline of a terrapin buried in the soft mud beneath, takes it with his tongs; or a fisherman captures an occasional terrapin with a net haul of fish.

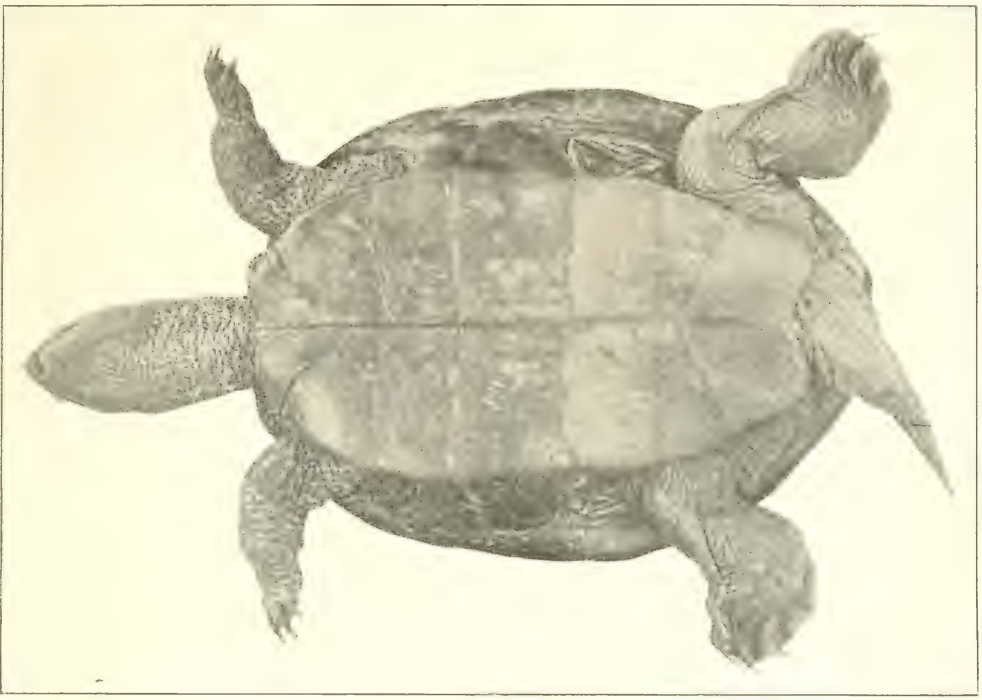
ABUNDANCE.

So rare and so well concealed are the terrapins that sometimes an expert fisherman may search every day for a week without finding one; again, only one is found on a trip, while another day, half a dozen or even a dozen or more may be obtained. They are not abundant enough in the region of Beaufort to make it profitable to an ordinary fisherman to hunt them. The majority of the terrapins obtained are either "bulls" (Plate III, A and B), as the males are called, or undersized "hens," as the females are designated (Pls. V and VI); and these yield the fishermen only 10 to 25 cents each. Only the larger females (5 inches or more, length of plastron) bring good prices. Hence, even a catch of 5 or 6, if all "bulls" or small "hen" terrapins, might not be a profitable day's work.* I know of but one man about Beaufort who may be accounted a terrapin hunter, and he hunts only at certain seasons and as long as there is little else to do in the way of fishing. Having hunted interestedly and more or less regularly in this way for many years, Mr. Evert Guthrie's experience as a collector was of invaluable assistance to us. In Pamlico Sound the search is probably more profitable, for the writer has more than once seen fishermen hunting terrapins by the seine method, as about Judiths Island and Pains Bay. (See Pl. IV, A).

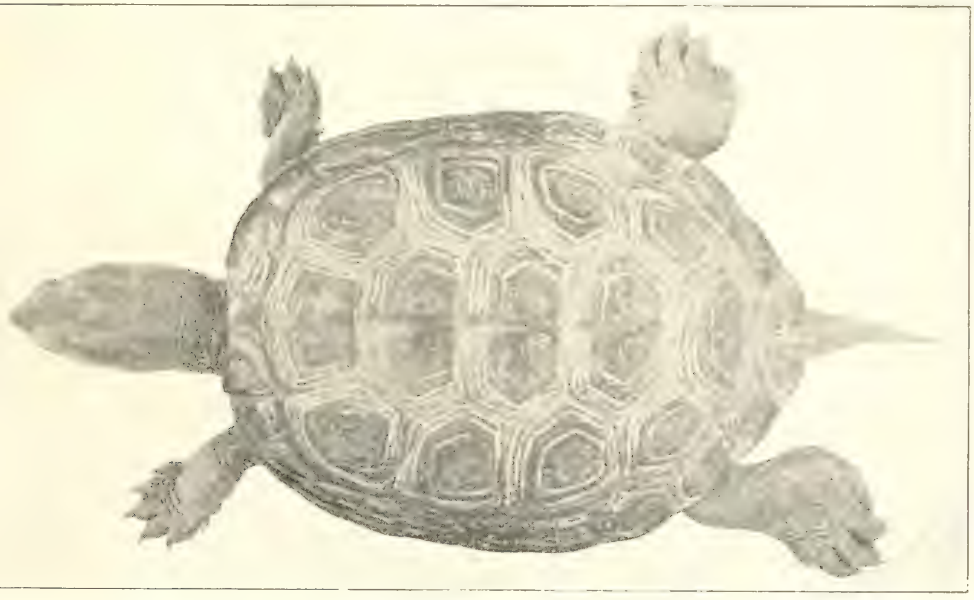
FOOD OF THE TERRAPIN.

The following is a record of the stomach contents of 14 small or medium-sized terrapins killed shortly after capture, all of which were taken in Beaufort Harbor:

* For market purposes the length of a terrapin is the length of the flat plastron (bottom shell), measured on the median line, and expressed in inches. For convenience, this method of measurement was adopted and is used throughout this paper.



B. VENTRAL VIEW OF THE SAME.



A. DORSAL VIEW OF ADULT MALE; LENGTH OF PLASTRON, 4 INCHES. TOP SHELL 4.6 INCHES.

A, BIRD'S-EYE VIEW OF MARSHES IN NEWPORT RIVER NEAR BEAUFORT, N. C., A TYPICAL HABITATION OF TERRAPINS.

B, VIEW OF SAND MOUND ON A MARSH WHERE TERRAPINS LAY EGGS.

STOMACH CONTENTS OF TERRAPINS.

Specimen Number.	(a) Litorina Irrorata Say (Snail).	Other Gastropods.	Crabs.	Annelids (Worms).	Remarks.
(b) 1	Fragments of 2.		Fragments of 1 (sp. undetermined).	Twenty-five pairs of jaws, apparently of a species of *Nereis*.	An abundance of mud.
(c) 2		About 100 very small snails. L. 1-2 mm.	Fragments of 1 (sp. ?).		Little in stomach.
(d) 3	Fragments of 6.	Fragments of 3 (*Melampus lineatus*, Say).			Five pieces of grass aggregating in length 32 mm.
(e) 4			Tip of claw of crab (sp. ?).		
5	Fragments of 153.		Fragments of 1 (*Gelasimus*).		One small piece of grass (sp. ?).
6	Fragments of 93.				
7	Fragments of 7.				
8	Fragments of 16.		Fragments of 1 (sp. ?).	Head and anterior segments of *Nereis* (*irritabilis*, Webster?).	One bulb from sargassum and a few shreds of grass.
9	Fragments of 9 with many more.		Tip of claw (sp. ?).	Setæ and 1 pr. of jaws of *Nereis* (sp. ?).	Shred of grass.
10	Fragments of 30.	Fragments of a *Melampus lineatus*, Say.			
11	Fragments of 53.				
12	Fragments of 8.				
13	Fragments of 51.				
14	Fragments of 46.				

a. The number could be counted accurately by using only the apices of the shells.
b. 2.3 inches, length of plastron, found on "Town Marsh" August 17, 1905.
c. 2.8 inches, length of plastron, found on "Town Marsh" August 17, 1905.
d. 3.5 inches, length of plastron, found on "Town Marsh" August 17, 1905.
e. 4.5 inches, length of plastron, found on "Town Marsh" August 17, 1905.

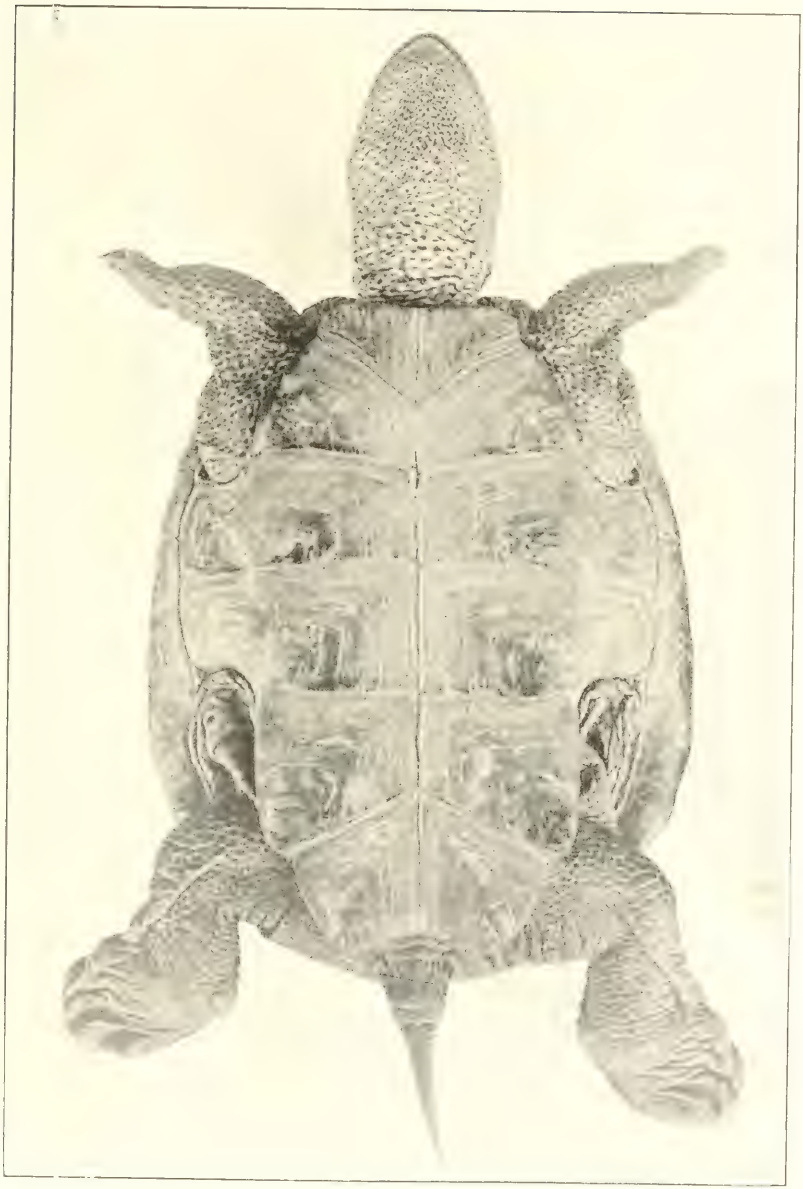
This limited number of observations indicates that the chief food of the terrapins at Beaufort is the small snail, *Litorina irrorata* Say, exceedingly common on the blades of marsh grass (*Spartina*); small crabs, such as the fiddler-crab (*Gelasimus*); and at least one species of annelid worm. The shreds of grass were, possibly, taken in accidentally while biting at the snails on the grass, for if the terrapins were by taste vegetable feeders, grass would, doubtless, have been found in much greater abundance. In confinement, terrapins will eat fish or blue crabs, etc., but in nature, the animals mentioned above are more accessible to terrapins than are larger and more active forms.

Since it is probable that the food has much to do with the quality of the meat of the terrapin, it would be essential for the purposes of the practical breeder to know definitely what is the natural food of the diamond-backs in the localities where the best specimens are found. Hence, it is important that more complete observations be made on this subject, especially on the feeding habits of terrapins in different geographic regions and in different localities.

HIBERNATION.

On the approach of cold weather the terrapin buries itself in the mud, probably often seeking this in the deeper waters. That this is not always the case is inferred from the fact that terrapins are said to be found in winter on the high marshes. Observations in an experimental pound lead to the belief that they commonly seek the deeper water.

DORSAL VIEW OF A DIAMOND-BACK TERRAPIN (YOUNG FEMALE) 4 INCHES LONG.



VENTRAL VIEW OF A DIAMOND-BACK TERRAPIN (YOUNG FEMALE) 4 INCHES LONG.

CHAPTER III.

OBSERVATIONS ON TERRAPINS IN CONFINEMENT.

The rarity of the diamond-back terrapin makes it difficult to observe their habits in nature. On this account and for other reasons in accord with the original aims of the investigation, it was determined to construct observation pounds within easy reach of the Laboratory. Near the northeast point of Pivers Island, on which the Fisheries Laboratory is located, there is a gradual but steady slope from the line of low tide, through a grassy marsh, to a higher sandy ground beyond the line of high tides. Such a spot afforded a most favorable location for a pound (or "crawl," as it is sometimes called); for it was desired to have a pound that would include as much variety of natural environment as could be had within the necessarily small space. Here a pen 25 by 90 feet might embrace sandy ground, always above water and suited for crawling or laying; grassy ground usually above water; a muddy and grassy tide-marsh; and, by extending below the line of lowest tides, a soft muddy bottom covered with never less than about 2 feet of water.

CONSTRUCTION OF TERRAPIN POUND AT BEAUFORT, N. C.

The wall of the pound (see Pls. VII and VIII) consisted of a double row of puncheons (pine slabs were used) reaching well into solid earth and extending about 4 feet above the ground or the level of the water at high tide. The puncheons of the 2 rows, placed with flat surface against flat surface, were so alternated that each slab covered the crack between the 2 puncheons of the other row. The slabs were nailed together and the wall was further strengthened by a 2-inch by 4-inch scantling laid horizontally on the top and nailed to each slab. Finally, a 10-inch plank placed horizontally on top of the scantling contributed especially to the rigidity of the wall, besides affording a convenient walk-way from which to observe the terrapins in any part of the pound. In addition, it served to prevent the terrapins from crawling out of the pen; for it was found that in the corners of the wall they could crawl up to the very top. The pound was divided into two compartments (10 and 15 feet wide respectively) by a partition similar in construction to the side walls and parallel to

them (Pl. VIII). The walls were not so close but that they freely admitted the water and even small fish and shrimps.

While this pen, built in September, 1902, was of satisfactory design in most respects, and served the purpose of an observation pound during the fall, winter, and spring following, the slab puncheons proved entirely inadequate. About July 1 of the following summer, after the sudden loss of a number of the terrapins, it was found that the slabs were disastrously worm-eaten near the bottom. It was necessary to make considerable repairs to the pen, or to permanently remove the remaining terrapins. By this time, too, it had been found that so small a pen was not adapted for breeding; that if the experiment was to be continued a very much larger pound should be made, and for this a different location would be required. Such a pound has now been established in Maryland by the United States Bureau of Fisheries, and the results of the breeding experiments will be as available and of as equal value as though made at Beaufort. (See Chapter V).

Observations were made on terrapins in these pens and on others in very small pens (3½ by 9 feet and 6 by 16 feet) supplied with the natural flow of fresh water from an artesian well. At times, too, terrapins were kept in aquarium tables (3 by 9 feet) or aquaria in the Laboratory.

BEHAVIOR IN CONFINEMENT.

When first placed in the pounds, the terrapins were confined for two weeks to a small portion at the upper end. There was a marked difference in the behavior of the terrapins in the limited freedom of the pound and that of those in the closer confinement of an aquarium table or one of the fresh-water pens. In the former a beaten path was formed where they often wandered along the walls, apparently seeking an opening for escape. They would attempt to climb over the walls, ascending in the corners of the pens several feet from the ground or water; for the rough bark of the slabs afforded sufficient hold for their feet. Usually, however, most of them were in concealment. Although one of the divisions contained over 40 and the other about 50, not until the following spring were considerable numbers in evidence at one time. It would hardly have been believed that the full number were still in the pound if the terrapins had not been hunted out and counted over. A number would appear at the

EXPERIMENTAL TERRAPIN POUND AT FISHERIES LABORATORY, BEAUFORT, N. C.

rapping to which many of them had been made accustomed as the call for food; but hardly more than a half-dozen would come to the feeding-board while a man stood near. Perhaps the gastropods, fiddler-crabs, shrimps, and other small animals, living in the pen or entering naturally through cracks, afforded almost sufficient food. In time this wildness wore away in some degree, but not until after 8 or 10 months did they become even tolerably tame. However, in the smaller pens and tables (nothing over 16 by 6 feet in size) the captives were more in evidence, and soon became quite tame, so much so as to crowd over one another in attempting to eat from the hand.

ASSOCIATION OF SOUND OR LIGHT WITH FOOD.

Diamond-backs very quickly associate certain sounds or other impressions with food. Fish and crabs were fed them daily, these being chopped near the pen with a hatchet. After a few days, at the sound of the chopping their heads would appear above their beds of weed. In time this sound, or similar sounds of rapping on the walls of the pen (whether or not food was present), became quite effective in bringing them out to the place of feeding, and thus they could be called from concealment whenever desired.

Later, some were fed in the evening after dark for a period of about a week. Soon the appearance of a lighted lamp became associated with food and was sufficient to draw the animals out to the place of feeding, whether or not there was food at hand.

FOOD AND WATER.

The writer would have little to say under this head were it not that actual observation of a great many pens of terrapins, kept for varying lengths of time between capture and shipment, has emphasized the importance of great consideration being given to the food and water for the terrapins. Terrapins withstand extremely unfavorable circumstances for so long a time that the impression is often gained that such conditions are not hurtful. Not infrequently the statement is heard from persons of experience that terrapins must not be fed oftener than twice or at most three times a week, or there would be a high rate of mortality; that the terrapins are gourmands. Undoubtedly the basis for this idea is actual experience in feeding terrapins in pens that are not supplied with a free current of water, enough to remove the filth which accumulates. Thus, the oftener the

animals are fed the more rapidly does the pen become foul and the more unfavorable become the conditions in the pen. It is unnecessary in this connection to do more than allude to the most frequent mistakes made in the manner of keeping terrapins:

1. The pen is insufficiently supplied with water. In one instance the reverse was the case, no land being supplied on which the terrapins might come up out of the water.

2. A very large number of terrapins are crowded within a very small enclosure.

3. Such individuals as die are left to decay in the water in which the other terrapins live and feed.

4. A series of pounds are so grouped that the waste from one pen passes into another, and the accumulated filth of these two into a third, and so on.

Unsanitary conditions must result from the above practice of handling terrapins. Such mistakes it would seem would be avoided by any one who recalled that the natural home of the terrapin is on the marshes that are daily swept by the tides, thus insuring constant supplies of fresh water. The essential consideration in keeping terrapins is to keep the pen clean, and to this end an effective flow of water is indispensable (but not necessarily all-sufficient). When kept under proper conditions, terrapins may be fed daily with chopped fish or crabs, live fiddler-crabs or marine snails, etc. Proper conditions can readily be obtained at any point on the coast, with but a small additional expense, and this will be more than counterbalanced by the prevention of losses from death.

HIBERNATION.

Hibernation (in the salt-water pound) began about October 22d. The terrapin did not at once hibernate permanently, but, according as the weather was warm or cool, many of them would be out or in concealment; but by the middle of December the terrapins were in regular hibernation. Even during the winter, however, individual terrapins were occasionally seen swimming sluggishly at the surface. Thus, though the weather was quite cool (freezing at night), one terrapin came out December 17th, and another on the 19th; but none would come up to feed.

After hibernation had begun, about 40 females, not included in the permanent experiments, were placed in an upper part of one division

INTERIOR VIEW OF EXPERIMENTAL TERRAPIN POUND, BEAUFORT, N. C.

of the pound, separated by a partition from the marsh and water of the lower half. These by December 19th had buried as best they could under the roots of the grass, being more or less completely covered by a thickness of an inch or two of roots and sand; for terrapins cannot burrow well in dry earth; and over them was thrown a pile of excelsior. In one corner two were found buried in the soft sand against the puncheons to a depth of about 4 inches. All of these terrapins were in a very stupefied condition, but, when taken in the hand, evidences of life were seen in slow and slight retractile movements of the neck and limbs. Placed in the warm sunshine, most of them soon began to crawl sleepily about. The terrapins shown in the photograph, Pl. IX, A, were taken from their winter quarters in the lower part of the pound, January 15, 1903. They had been in the sun long enough to begin crawling about, but were quiet enough for an exposure of one second of the camera, Pl. IX, B.

Some of the terrapins in the pound, especially the smaller ones, buried in the muddy marsh, but most of them used the soft, water-covered mud at the very outer end. They were so lightly buried that the position of many of them could readily be distinguished. On warmer days, during the winter, the slow movements of a terrapin just beneath the surface of the mud might be watched through the water, or a terrapin might be seen to come out of the mud, crawl slowly over the bottom for a foot or two, and then bury itself again. Thus they were not entirely inactive, although they did not, so far as was known (occasional individuals excepted), come out either to eat or breathe in the air.

It was interesting to note, on the other hand, the behavior of other terrapins kept under different conditions, as in the small fresh-water pens which have been previously alluded to. The temperature of the water from the artesian well is 20.4° C.; after running, however, about 30 feet over the ground and into the pens, the walls of which caused it to form miniature "ponds," the temperature was considerably reduced in cold weather; but ice was not noted in these pens during the entire winter. On warmer days the terrapins would come out in numbers, and, after being in the midday sunshine awhile, would become quite active. Thus, on December 17th, when only one terrapin was observed out in the salt-water pound, a small "island" of sand in a fresh-water pen was covered with terrapins which, when approached, ran actively back into the water. On such days (not

infrequent), and coming at any time during the winter, the animals were usually fed, and would eat quite heartily. Thus the statement often made that from the very beginning of hibernation in fall until its close in spring, terrapins cannot be induced to eat at all, may apply to terrapins under natural conditions, but does not apply to those kept under such artificial conditions as in our fresh-water pens.

While terrapins thus protect themselves from the rigors of winter, they may, as is well known to dealers, withstand severe cold, even freezing, for a short time.

The hibernation ended about March 8th. On that day the terrapins appeared in great numbers and seemed very lively. After that, many of them were out, chiefly swimming or floating in the water. Some fed heartily, but, as in the fall preceding, they were not very tame, and not many of them would come up to eat the food placed for them, except at night. They were commonly seen floating in groups on the surface while the tide was well up. By early summer they were much tamer and would come up more boldly to feed.

The writer visited Crisfield, Maryland, April 1st and 2d, and found the terrapins in the pounds there were apparently emerging from hibernation, thus being about three weeks later than at Beaufort, N. C.

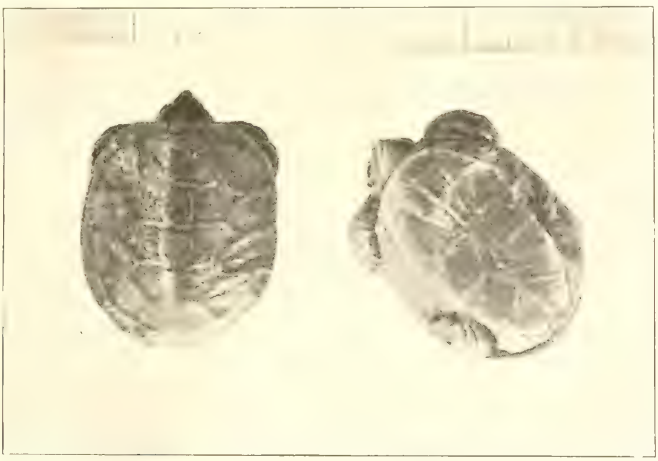
BREEDING.

While during April, May and June the terrapins were out a great deal, frequently floating or swimming languidly on the surface, mating was not observed. I do not know of any case of mating or laying in ordinary pens, except where terrapins were added during the spring or early summer.* In such cases only by careful observation could it be determined if the terrapins that had been in confinement during the preceding winter mated and laid.

Several terrapins, male and female, were taken and impounded during the spring of 1903. During the writer's absence, one of these, a female of between 5 and 6 inches (length of plastron), was observed making a nest on June 30, 1903. A few days afterwards the eggs were dug up. Two bunches of eggs, or two nests, were found about 4 inches apart (the two nests made by the same female?). In one of the nests were 6 small eggs, in the other 7 of varying size, but all larger than any of the six. To get at these eggs, it was necessary

* Professor Hay has informed me that in the experimental pounds of the Bureau of Fisheries, located in Maryland, some of the terrapins mated after the *second* winter of confinement. See below, p. 36, Chapter V.

A, GROUP OF SMALL TERRAPINS TAKEN FROM EXPERIMENTAL POUND AT BEAUFORT, N. C.



B, NEW-BORN TERRAPINS, SLIGHTLY ENLARGED.

to remove 4 or 5 inches of sand with bits of shells and other solid matter. The ground was probably unsuitable, for the eggs were not planted as deeply as in nature and most of them failed to hatch. One hatched a terrapin that was taken from the nest August 26th, 57 days from date of laying. Another was found in the nest September 13th, 75 days from the date of laying. On the dates mentioned, the nests were opened and in each instance one terrapin was found in the nest out of the shell, or in the sand just above. The exact date of hatching cannot be given; the examination might have been made a few days earlier or later with similar results. The young of the yellow-bellied terrapin *Pseudemys rugosa* are known to remain in the nest until the following spring, as described by Dr. Hugh M. Smith.* The young of *Malaclemmys centrata* probably leave their nest not long after hatching. (See Pl. IX).

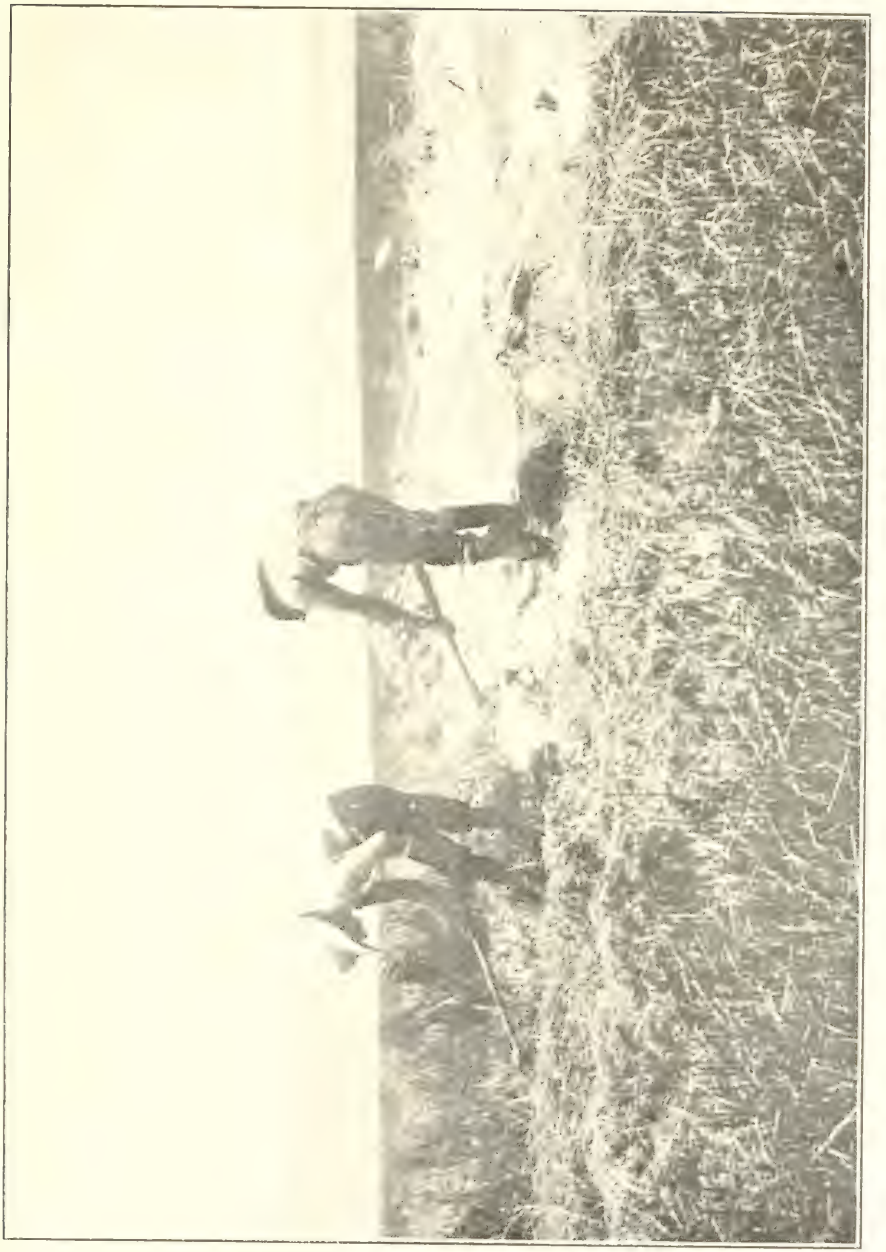
* "Notes on the Breeding Habits of the Yellow-bellied Terrapin." Smithsonian Misc. Coll. (Quart. Issue), Vol. XLV, April 4, 1904.

CHAPTER IV.

REPRODUCTION OF TERRAPIN IN THE WILD STATE.

LAYING HABIT IN NATURE.

The marshes of Beaufort Harbor and tributary rivers are usually very low and, except for the tops of the grass, completely submerged at high tide. In a very few spots the winds and waves have beaten up sandy lumps that have been rendered stable by grass roots and are exposed at all times except during very high storm-tides. Such elevations on one of the "Middle Marshes," between the mouth of North River and Shakleford Banks, seemed to offer very favorable places for nesting; it was known, too, that new-born terrapins had been found there once before. On the 21st and 22d of July the writer made a search of two of the three lumps on this marsh (see Pl. IV, B, and Pl. X). The ground was dug up carefully, and, in 3 or 4 hours digging, 7 nests were discovered. On one lump 4 nests, containing 4, 5, 6 and 7 eggs respectively, were found at depths of 6 to 8 inches; except that the nest with 4 eggs (the only one not on the highest part of the elevation) was only 3 inches below the surface. This nest contained only small eggs. On the other lump were found 3 nests of about the same depths with 2, 5 and 8 eggs respectively. Perhaps not more than one-half of the ground was dug, for it was not desired to disturb other nests. In each lump the higher part was 20 to 30 feet long by about 6 feet wide. With one exception, the nests were found on the highest part, which could be submerged only by a very high storm-tide. The third elevation was not so high, was shelly and less promising in appearance, and was not examined for eggs. In digging, occasional bits of egg-shell were found, vestiges of former seasons. One old entire egg was found, through which a blade of grass had grown, and one of the new eggs found had met the same fate. Some of the eggs taken here and transplanted to Pivers Island had hatched by August 25th and 26th. On August 22, 1902, a nest of 3 terrapins had been found here by the collector, Mr. Guthrie. One of the terrapins, he stated, was found emerging from the shell.



HUNTING TERRAPIN EGGS NEAR BEAUFORT, N. C.

THE YOUNG TERRAPINS.

The new-born terrapins have soft shells (Pl. IX, B) and, doubtless, in their defenselessness, much loss is suffered during the first year from rats, crows, and other enemies.* In The Common Crow of the United States† Barrowes makes the following interesting note regarding the depredation of crows on young tortoises, though he does not mention the diamond-back, probably because the observations were not made on crows at the seashore:

> The examination of crow stomachs brought to light the somewhat unexpected fact that crows destroyed considerable numbers of young tortoises, or terrapins, as they are generally called in Maryland and Virginia. This item of food is noticeable during April, May, and June. Only young tortoises are eaten, those of very small size predominating, though occasionally larger ones are taken. (The snapping tortoise, *Chelydra serpentina*, the painted tortoise, *Chrysemys picta*, and the box tortoise, *Cistudo Carolina*, mentioned) * * * in May (this kind of food) formed almost 1 per cent, occurring in 33 stomachs out of 364, or in about 1 stomach out of every 11.‡

We could almost imagine the extermination of the race in this way in a few years, were it not for the remarkable success of the young in concealing themselves, at least from man. In the course of two years, 15 terrapins each with 2 rings of growth were found. Hundreds of terrapins older than this could have been obtained. I think two specimens of the new-born size were brought to the Laboratory (besides those found in the nests) and one specimen with one ring of growth. These were chance specimens. Not a single terrapin under two years of age rewarded the many careful searches of an experienced terrapin hunter, though the young must be much more abundant than the older forms.

It is of interest that on two of the only three occasions when terrapins of two years of age were taken, they were found in groups. Thus on one day 6 were found within a small area in Gallants Creek; on another day, 9 were taken not far apart.

* Raccoons, crows, minks, hogs, rats, etc., are said to destroy eggs and young.

† U. S. Department of Agriculture, Division of Ornithology and Mammalogy, Bulletin No. 6, 1895, pp. 48, 49.

‡ He quotes also from Mr. Richardson: "The crow is known to catch young terrapins, and there is reason to believe that it destroys other small reptiles. I remember a rock-crowned hill on the east bank of the Wateree, between Manchester and Statesburg, in Sumter County, Ga. (intended for South Carolina), that was almost covered with remains of small terrapins and land tortoises carried there and devoured by crows."

Agassiz, speaking of a difference in habits of the young and adults in some species of Chelonia, says:

> Nothing could prove more directly this difference in the mode of life of the young and adult than the fact that though *Emys insculpta* is so common in the neighborhood of Lancaster, about 40 miles from Boston, that I have at times collected over one hundred in an afternoon, aided by a few friends, I have never yet been able to obtain a single young specimen of the first year, even though a whole school of men were called in to aid in the search. Professor Baird has found the same difficulty in obtaining young *Emys rugosa* for me.*

It is reasonably certain that the young of diamond-back terrapin, as of some others, do not begin to eat until the following spring. New-born terrapins kept until spring, as well as a specimen collected in the spring, show no evidence of post-embryonic growth.

RATE OF GROWTH.

To determine the practicability of breeding, it is quite important to know the rate of growth. Unfortunately we cannot well follow the life-history of individual terrapins in nature, but we may, from the markings of the horny scutes of the carapace and plastron, compute with approximate certainty the ages of some terrapins of various sizes. Judging from such evidences, terrapins seem as variable in rate of growth as in so many other respects.

The manner of growth of the shell may first be briefly recalled. The horny shield of a terrapin is covered by thin, horny scales or scutes, disposed in several series. As the terrapin grows each scute extends its area peripherally and, commonly, in all directions. Thus, with each period of growth, a ring of new tissue is added, separated from the central area (*areola*), or the preceding ring, by a line of depression. While these rings are spoken of as "concentric," the term must be taken with a reservation, for growth is not equal in all directions. On the contrary, all scutes, except those of the anterior margins of carapace and plastron, grow more anteriorly than posteriorly: hence the rings are decidedly *eccentric*, the center of each ring being (on most of the scutes) anterior to that of the preceding ring (see Pl. XIV, A and B, and Pl. XV). Agassiz interpreted these rings as representing annual periods of growth,† and my observations con-

* Louis Agassiz: Natural History of the United States, Vol. I, p. 294.

† * * * "We find upon the surface of each scale, around a small angular central plate (the plate of the first year's growth) [*i. e.*, the year of the incubation—R. E. C.] a smaller or greater number of concentric stripes or regular annual rings, as they are exhibited on a transverse section of an old tree." Loc. cit., p. 259.

firm this interpretation, with the qualifications to be given in succeeding paragraphs. Thus, in case of terrapins carefully described and marked and kept for a year, the growth (slight in close confinement) could, before measurement, be detected from the new ring on each scute. Two terrapins hatched at the Laboratory presented, after two seasons of growth, two distinct rings around the *areola* on each scute.

Undoubtedly, it is true, as a rule, that a distinct line of depression represents a period of cessation from growth; and, consequently, that the rings between successive lines represent the growth of a year. When, however, an attempt is made to compute ages from the numbers of rings, several complications are met with:

1. Doubtless any period of cessation of growth produces a more or less distinct line. Often when the annual rings are distinct enough, each ring is seen to be faintly subdivided (see Pls. XI and XV); and again these subordinate lines may be so distinct, or the main lines so indistinct, that it is quite impossible to decide with any assurance how many years are represented by the rings observed. (cf. Pl. II, B).

2. Many shells, particularly the older ones, have become very smooth through the shedding of the outer horny layers. For while the rings are not merely superficial, but are engraved in the bones beneath, yet, when the outer layers of horny matter peel away, the bone itself becomes smooth, and the rings may be entirely obliterated. (See Pl. II, A, and cf. text below, p. 33).

3. In older terrapins the growth is so slow and the rings are so small that they cannot ordinarily be distinguished.

As a result of one or more of these complications, the age of a given terrapin cannot usually be stated with satisfactory assurance. Ordinarily the rings of the younger terrapins (aged 1 to 3 years) can readily be interpreted; but one commonly puts down an older terrapin with a feeling of uncertainty as to the number of years represented by the rings. No other apology, then, need be made for the small amount of data offered here in regard to rate of growth. The data that follow are given for what they are worth, with the understanding that there is not to be inferred from them the *average* rate of growth of our diamond-back terrapin.

New-born terrapins measure about 1 inch, length of plastron,* and this may be taken as, approximately, the average length at the close of the winter following the season of post-embryonic growth (Pl. IX, B). There is, however, much variation in size and shape at birth. The actual measurements (in inches) of four were:

SIZE OF NEW-BORN TERRAPINS.

Number.	Inches.
1	1.10
2	.98
3	.96
4	.96

Only one terrapin was found with one ring of growth. This one was taken May 28, 1904, and it measured 1.76 inches. As the ring was undoubtedly formed during the preceding season, the growth during that season was about ¾ inch. Pl. XI, A, shows the beginning of the formation of the first ring of growth.

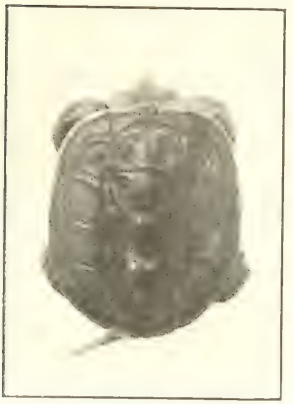
The length of 14, each of which had two distinct rings of growth, were:

LENGTH OF TERRAPINS WITH 2 RINGS OF GROWTH.

Inches.	Inches.
2.62	3.04 (v. Pl. XI, C)
2.72	3.04
2.74	3.06
2.74	3.12
2.78	3.14
2.84	3.24
2.84	
2.92 (Pl. XI, B)	

The average of these lengths is 2.83 inches (range 2.62 to 3.24). Thus in 2 years the increase has been about 2 inches. The comparative widths of inner and outer rings indicate that growth was greater during the first year than during the second up to the time of capture; but as these terrapins were taken and measured in the latter part of August, the growing season was hardly three-fourths gone.

* As to manner of measurement, see footnote, p. 14, above.



A. YOUNG TERRAPIN FROM TEXAS, SHOWING BEGINNING OF FORMATION OF FIRST RING OF GROWTH.

B. TERRAPIN WITH 2 RINGS OF GROWTH, 2.92 INCHES LONG.

C. TERRAPIN WITH 2 RINGS OF GROWTH 3.04 INCHES LONG. SHOWS BEGINNING OF THIRD RING OF GROWTH.

The difference at the end of the season would doubtless have been slight. Pl. XI, B and C, show terrapins with 2 rings of growth. In Pl. XI, C, the rings are seen to be faintly subdivided.

Taking an individual terrapin with two rings—one of those measuring 3.04 inches, for example—we may by addition of the several measurements of the *areolæ* of the scutes of the plastron, of the inner rings, and of the outer rings, respectively, compute that at birth the length of the plastron was about one inch; that during the second season, the first season of growth, the length increased by 1.1 inches; and during the second season of growth, up to September, by 1.9 inches. It seems, therefore, that during the first two years terrapins grow about 1 inch each year.

In older terrapins, the next few rings are slightly narrower. The sizes of 7 females and 4 males, each with 3 rings of growth, were:

LENGTH OF TERRAPINS WITH 3 RINGS OF GROWTH.

Females.		Males.
Inches.	*Inches.*	*Inches.*
3.19	3.92	3.04
3.61	4.06	3.31
3.86 (Pl. XII, A)	4.38	3.56
3.87		3.63

The average size of the females was 3.84 inches (range 3.19 inches to 4.38 inches); of the males, 3.38 inches (3.04 to 3.63 inches). As these terrapins were captured and measured at about the same season of the year as were the terrapins of 2 rings, the gain may be taken as that of a full year. This is, for females, nearly an inch; for males considerably less. At this age males are readily distinguished from females by the size and shape of the tail. Presumably, too, the secondary sexual character, of slower growth, has asserted itself by this time so that a difference such as that indicated in the figures above may be characteristic at this age. Pl. XII, A and B, and Pl. XIII, A, show terrapins with 3 rings of growth.

Two females, each with 3 rings, selected at Crisfield, Maryland, in April, 1903, measured 4.7 inches (Pl. XIII, A) and 3.9 inches, respectively. These were of course somewhat older than the terrapins on which were based the measurements given above, for the two in question had completed their third season of growth.

A specimen seen in the Baltimore market with 4 rings, distinct and unmistakable, measured 5.6 inches length of plastron.

The measurements of 9 females and 7 males, each with 4 rings of growth, were as follows:

LENGTH OF TERRAPINS WITH 4 RINGS OF GROWTH.

Females.		Males.	
Inches.	*Inches.*	*Inches.*	*Inches.*
3.98	4.50	3.04	3.68
4.04	4.56	3.50 (shell)	3.96
4.06	4.58	3.56	
4.28	4.70 (Pl. XIII, B)	3.60	
4.40		3.64	

The average for females is 4.34 inches (3.98 to 4.70 inches), for males 3.57 inches (3.04 to 3.96 inches). Comparing these averages with those given for terrapins with 3 rings, a gain of a little over ½ an inch (0.6 inch) is indicated for females, with but a slight increase (0.19 inch) for males. The latter are now nearing their adult size. The shell of a female with 4 rings is shown in Pl. XIII, B.

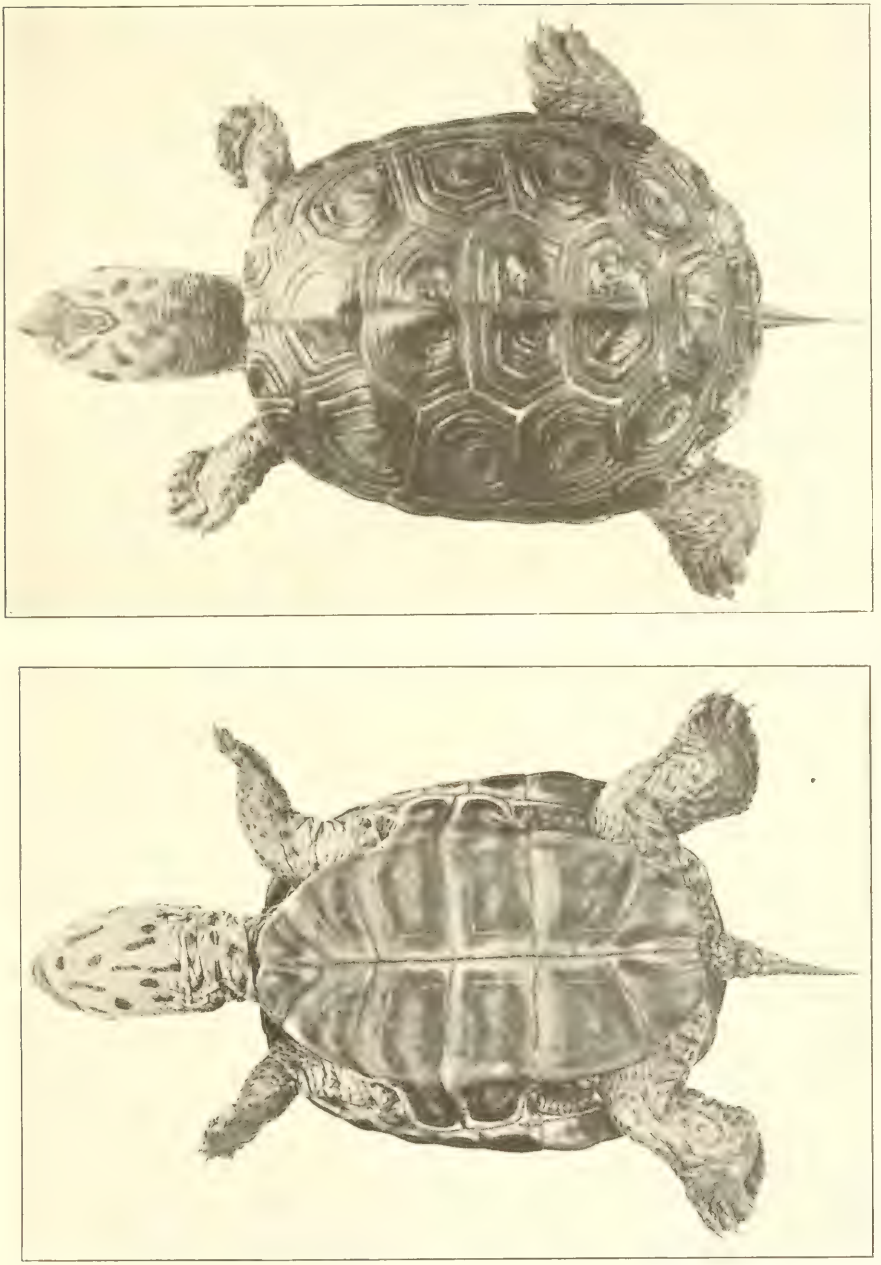
Only a few showed 5 (and only 5) rings distinctly. Their measurements were:

LENGTH OF TERRAPINS WITH 5 RINGS OF GROWTH.

Females.		Males.
Inches.	*Inches.*	*Inches.*
4.10	5.34	3.74
4.22	5.40	4.14
4.48	5.60 (Pl. XIV, A)	
4.74		

The average for females, 4.84 inches, compared with the average for females with 4 rings (4.34 inches), suggests a growth during the fifth year of about ½ inch. Three of the above, however, are more than ½ inch above the average for the seven, and show that a growth of about 4½ inches during the first five years of growth is possible. Five rings may be counted on the shell shown in Pl. XIV, A.

It is not often that more than 5 rings can be counted with assurance, but a few specimens may be mentioned:



A AND B, DIAMOND-BACK TERRAPIN (FEMALE) WITH 3 RINGS OF GROWTH, 3.86 INCHES LONG.

A, SHELL OF DIAMOND-BACK TERRAPIN (FEMALE) WITH 3 RINGS OF GROWTH, 4.7 INCHES LONG.

B, SHELL OF DIAMOND-BACK TERRAPIN (FEMALE) WITH 4 RINGS OF GROWTH, 4.7 INCHES LONG.

LENGTH OF TERRAPINS WITH 6, 7, AND 8 RINGS OF GROWTH.

Females.		Males.	
No. Rings.	*Inches.*	*No. Rings.*	*Inches.*
6	4.2	7 (4?)	5.5
	4.3		5.9
	4.4 (Pl. XIV, B)		6.4
	5.4	8	5.5 (Pl. XV, fig. 3)
6 (+?)	5.3	9	5.5
	5.4	11	6.2
7	5.4	12	6.8

I have, however, examined very few 6-inch terrapins with reference to rings, and to judge from the range of sizes of terrapins with 5 rings, it is probable that with the observation of a larger number of 6-inch terrapins we would find some with fewer rings. Thus, among a number of terrapins seen in the Baltimore market, a specimen was observed that had only 7 rings, but measured 7¼ inches, length of plastron.

Two terrapins hatched from eggs laid at the Laboratory (referred to on p. 23 above) were living in the summer of 1905. They have lived all the time in a pen 6 by 12 feet, supplied by a small stream of fresh water. As no one was charged with their care, they were fed very irregularly, and it was to be expected that they would grow very slowly. Two years after they hatched, they measured 2 inches and 1.9 inches respectively. The larger one is shown in Pl. XV, figs. 1 and 2. The first ring of growth is broad and more or less subdivided; the second ring of growth is very small.

As has been stated, we cannot infer from the small amount of data given, the *average rate of growth of Malaclemmys centrata.* The figures indicate possibilities and serve to show the wide variability of terrapins in respect of growth. The female of Pl. XIV, B, was forming its sixth ring when killed, but it was only 4.4 inches in length of plastron; while we find terrapins with only 5 rings that are about 1¼ inches longer.

To sum up the observations on rate of growth:

A good rate is an inch or more each year for each of the first 2 years, slightly less during the third year, and about ½ inch for each of the next two years. The average rate may be less, or, probably,

more. Sometimes growth is more rapid, the terrapin reaching a length of 5½ inches in 5 years.

A market size, 5 inches ("half counts"), may be attained in 5 years, but this is probably not the rule. Probably few 6-inch terrapins are less than 7 years of age and many may be still older when this length is reached.

The possibilities of growth in confinement can only be ascertained after more extended experiments.

It is possible that the great variability of terrapins in respect of rate of growth may offer an opportunity, if breeding becomes an accomplished fact, of materially increasing the average rate of growth by selecting for breeding purposes only those of more rapid growth.

VARIATION.

In almost every respect, diamond-back terrapins exhibit a remarkable degree of diversity. In color, for example, we find very light yellowish or greenish specimens, while others have a very dark green or an almost dead black carapace; all intermediate forms occur with various conditions of marbling on the plastron, or concentric rings of color on the scutes of the carapace, etc. Equally striking are the variations in sizes and shapes of the specks or spots on the lighter or darker background of the skin of the neck. Hay* has described the color variations of terrapins from Enterprise, N. C. The size of head, depth of body, contours of carapace and plastron, shape and size of new-born, and size of eggs; all these points are subject to much variation.

The marked diversity in the horny scutes, and in the bony plates underneath is treated by the writer in separate papers.†

Wide differences in activity, boldness, promptness to take food, etc., are very evident in penned terrapin; and perhaps as a result of these differences the rate of growth seems exceedingly variable.

Agassiz says: "This species varies most remarkably in its color and sculpture, as well as in the size of the head."‡

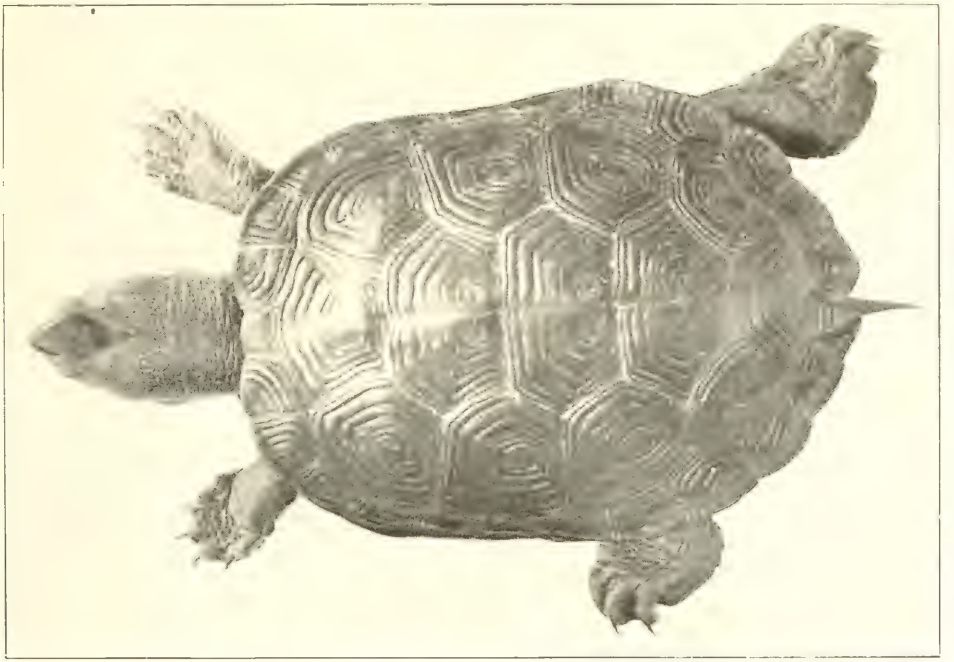
Bangs speaks of the "most extraordinary range of individual variations" and says: "It is hard to find two terrapins alike."§

* Loc. cit., p. 15.

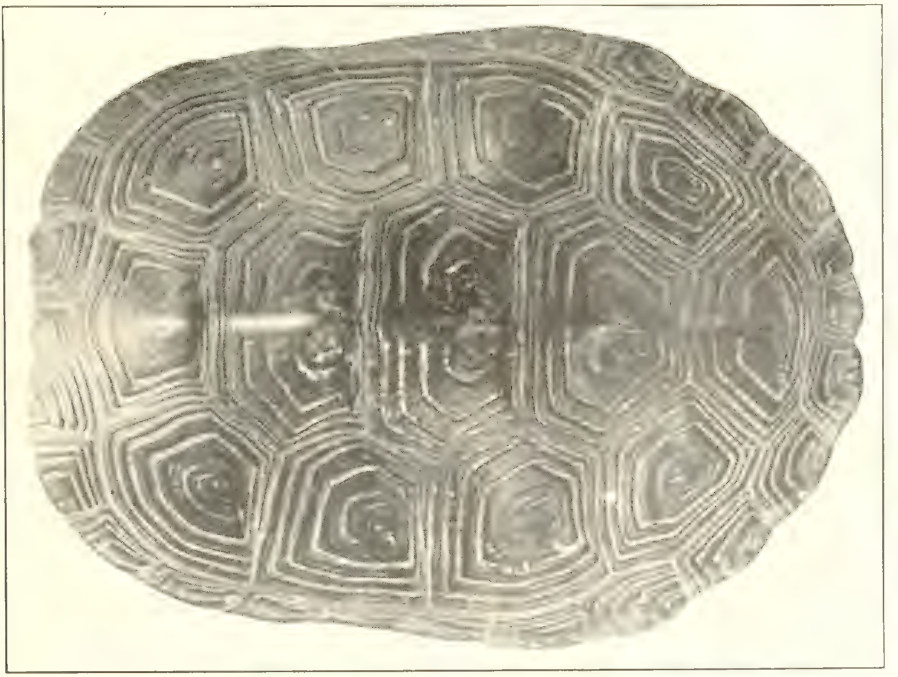
† "Diversity in the Horny Scutes and Bony Plates of Chelonia." Paper presented at annual meeting of Am. Loc. Zool., December, 1904. Abstract in Science, N. S., Vol. XXI, No. 532, 1905.
"Gadow's Hypothesis of Orthogenetic Variation in Chelonia," J. H. Univ. Circular, May, 1905.

‡ Agassiz, Loc. cit., p. 437.

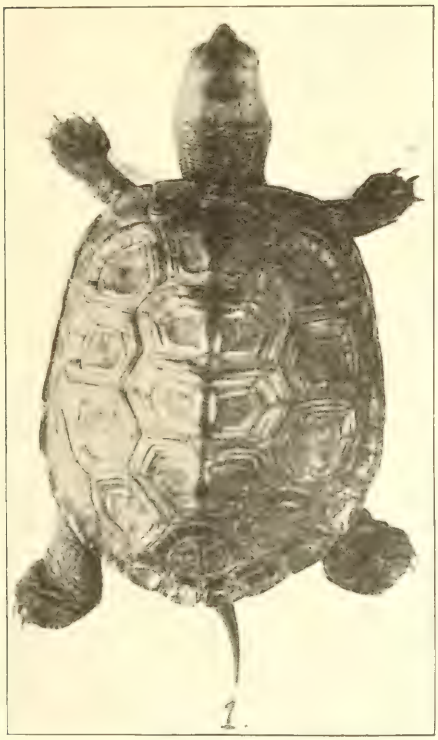
§ Bangs, Outram, "An Important Addition to the Fauna of Massachusetts." Proc. Boston Soc. of Nat. Hist., XXVII, pp. 159, 161.

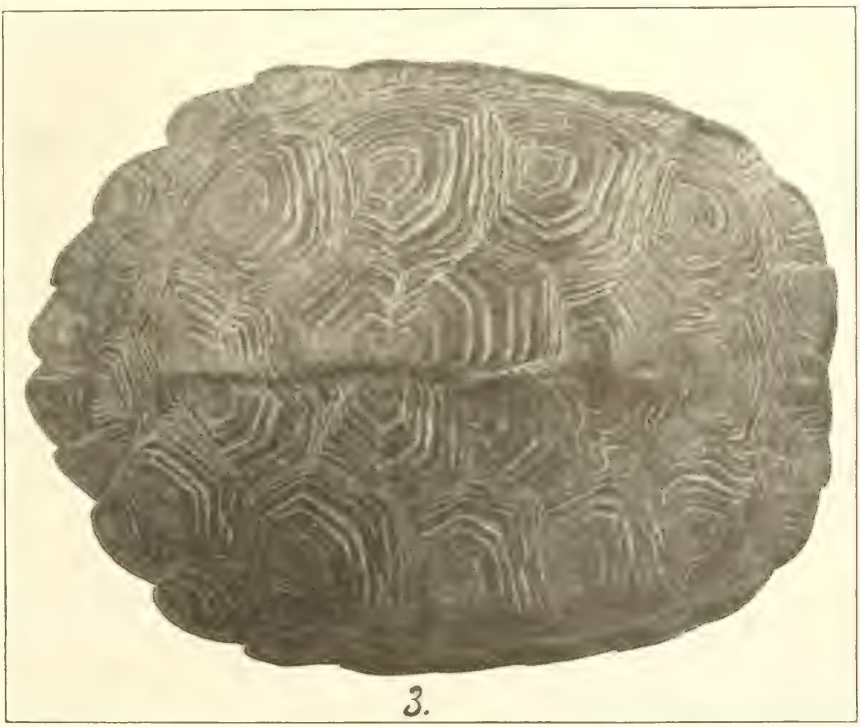


B. DIAMOND-BACK TERRAPIN (FEMALE) WITH 6 RINGS OF GROWTH, 4.44 INCHES LONG.



A. SHELL OF DIAMOND-BACK TERRAPIN WITH 5 RINGS OF GROWTH, 5.6 INCHES LONG.





FIGS. 1 AND 2, DIAMOND-BACK TERRAPIN 2 YEARS OF AGE, RAISED FROM EGG HATCHED AT LABORATORY. FIG. 3, SHELL OF DIAMOND-BACK TERRAPIN (FEMALE) WITH 8 RINGS OF GROWTH, 5.55 INCHES LONG.

MOULTING.

The diversity in respect of *moulting* has been referred to above in connection with the rings of growth. Agassiz thus refers to the moulting of Testudo:

> In Testudo the casting off of the old epidermis is very different in different species, and even in different specimens of the same species. I have seen in many adult specimens of *Xerobates Carolinus*, and still more distinctly in some old specimens of *Testudo radiata*, the central plate of the scales, that is, the plate of the first year, perfectly preserved with all its fine granules, so shaped, indeed, that it seemed as if nothing had been cast from their surface, while others were entirely worn out. These facts show that further observations are very much needed respecting the moulting of reptiles. Indeed, this subject requires to be studied anew in all vertebrata. (Agassiz, Loc. cit., p. 260.)

Sometimes in shedding specimens, the horny layer is so thin that the bony sutures show through it. It is of interest that, as has already been mentioned, the carapace becomes smooth by this process of moulting of the outer layers of the scutes. The sculpture of the shell is not a feature of the horny layer, alone, but is cut into the bone itself, so that the lines of growth, when present, show as well after the scutes are removed; yet after the casting of the outer horny layers, not simply the scutes, but the bony plates as well, lose their markings and become smooth. The sculpture of the bone seems to be an adaptation to that of the first-formed horny layers, and when the need of such adaptation is lost by the loss of these layers, the plates become smooth. Thus, in a specimen in which the *stratum corneum* of two scutes was scraped off with a knife without apparent injury to the bone, the horny covering was regenerated; but the concentric markings of the bone of the area operated on disappeared during the regeneration. Elsewhere they were as evident as before the operation.

DIFFERENCES OF SEXES.

After about the second year of growth, males and females are readily distinguished by the size and shape of the tail, the proximal part of the tail of the male being very prominent. Compare A and B of Pl. III, of a male, with A and B of Pl. II, of a female. There are other sexual differences, such as the smaller head of the male and the more wedge-shaped posterior outline of the carapace in the same sex;

but the most reliable and constant distinguishing character is the tail.*

It is well known that the males do not attain so large a size as the females. The largest male I have measured was 4.16 inches on the bottom shell, but a dealer informs me he has had a male measuring 5 inches. Females commonly attain a length of 6 inches, often of 7 or 8 inches. Mr. A. B. Riggins of Marshallburg, N. C., informed me that he had had a female measuring 9¼ inches, and that he once sold a dozen measuring over 8 inches.†

* Cf. Hay, Loc. cit., p. 15.

† The males are of very inferior value on the market, where they are quoted as "Bulls."

CHAPTER V.

CULTIVATION OF THE DIAMOND-BACK TERRAPIN AT LLOYDS, MARYLAND.*

SEASON OF 1904.

The cultivation of the terrapin at Lloyds, Md., was begun by the United States Bureau of Fisheries in 1904, and represents the continuation of experiments that had been carried on during the preceding season at the same locality by the Rev. E. L. Hubbard, who raised a few terrapins in a small pond. These formed the nucleus of the stock in the pond maintained by the Bureau of Fisheries, which was under the supervision of Professor W. P. Hay, of Washington, D. C. Early in 1904, a small pen, about 40 x 40 ft., was constructed by driving boards down into the marsh at the end of the pond, and the terrapin were transferred to it. Later in the season the pond was enlarged by the addition of four pens about 20 x 40 ft., and last summer another addition of one large pen about 40 x 80 ft. was made. The first stock consisted of the terrapins mentioned above, and these have since been kept carefully separated from all later stock. During the summer of 1904 about 150 terrapins of each sex, ranging in length from 3¼ inches to 7½ inches, were purchased and distributed in the pens. They were graded according to size (of the females), about 25 of each sex being placed in each pen. This was done in order to determine, if possible, the age at which the terrapin begins to lay and the number of eggs produced, and also to ascertain the rate of growth. As the season was so far advanced when the stock was purchased and so much of it was in poor condition, very little was accomplished, except to get the pen and its occupants into good condition for the following season. About 25 eggs were obtained, however, which had been laid by the original stock of terrapin. These were transferred to sand-boxes and in about 6 weeks they, all but one, hatched.

The young terrapins were put into a small pen by themselves. Their habits from the first proved to be very astonishing. They burrowed down into the ground and very rarely came to the surface, and

* Notes given in this chapter relate to the cultivation of the terrapin at the pounds located at Lloyds, Maryland, and have been furnished by the Hon. George M. Bowers, Commissioner of the Bureau of Fisheries.

never entered the water except by accident. They could not be induced to eat. When taken out of the ground and set free in their pen, some hid themselves at once, while others did their best to escape. They seemed to have no difficulty whatever in climbing up the straight sides of the pen, and before we became aware of it, we had lost over half of them. Thinking to prevent their exit, a board was fastened at right angles to the walls, shelf-like, all around; but even this did not stop them. It is difficult to believe that so clumsy a thing as a turtle can hang to the underside of even a rough board; but there were absolutely no holes in the pen through which a young terrapin could pass, and on one occasion one was found crawling along on top of the shelf. The pen was covered with wire netting; so the herons, etc., were not responsible for the loss, and we have no other explanation of the facts except that the young terrapin is a most extraordinary climber.

SEASON OF 1905.

The season of 1905 opened with everything in good condition, and in June some of the larger terrapin began to lay. During this and the following month about 120 eggs were secured and transferred, as before, to a box buried in and nearly filled with sand. Most of the eggs were laid in the pens containing the original terrapin (2 years at least in confinement); only a few of those purchased later produced eggs. Quite a number of the eggs were not fertile and of course remained unchanged during the 7 or 8 weeks that the fertile eggs required to hatch (this summer was colder than the preceding). About 75 young terrapin were secured and were put, early in September, into a separate pen. The young of the preceding year had escaped or died, with the exception of seven. Of these, one had attained (in September) a length of nearly 2¼ inches on the plastron, one had scarcely grown at all (original length about ⅞ inch), and the others ranged between. Such of the older terrapin as retained the tags put on them when measured and weighed immediately after purchase showed a growth ranging from ½ to 1-16 of an inch and a slight increase in weight. With these results the season of 1905 came to a close.

SUMMARY.

To sum up, the work at Lloyds has given us the following facts:

1. Terrapin will produce eggs when confined in a pen.

2. Some of the animals, at least, will lay after having been confined for at least two seasons. This is probably dependent upon their having plenty of food and an abundance of room.

3. Most of the eggs produced are fertile and most of them will hatch, even after having been transferred to suitable hatching boxes.

4. The young terrapins are very different from the adults in their habits. They do not enter the water nor do they take food until well along in the second season.

5. The adults do not seem to be disposed to devour their young, but on the other hand, they pay no attention to them, and would undoubtedly trample them to death or keep them from obtaining food if all were put into the same pen.

6. The rate of growth is exceedingly variable. The variation in the young may be due to sex, but in adult females it varies from practically nothing to about ½ inch per year.

7. Terrapins require an abundance of food. Crabs seem to be the favorite article, but they will also eat cabbage, fish, snails and such insects as may come within their reach. Their jaws are weak, however, and the food must be, ordinarily, chopped up before they can manage it.

CHAPTER VI.

CULTIVATION OF THE SNAPPING-TURTLE, OR SOFT-SHELL TORTOISE "SUPPON," IN JAPAN.

By K. MITSUKURI, Ph.D.*

INTRODUCTION.

The place occupied among gastronomical delicacies by the diamond-back terrapin in America and by the green turtle in England is taken by the "suppon," or the snapping-turtle, in Japan. The three are equally esteemed and equally high-priced, but the Japanese epicure has this advantage over his brothers of other lands—he has no longer any fear of having the supply of the luscious reptile exhausted. This desirable condition is owing to the successful efforts of a Mr. Hattori, who has spared no pains to bring his turtle farms to a high pitch of perfection and is able to turn out tens of thousands of these reptiles every year. As his are, so far as I am aware, the only turtle farms in the world which are highly successful, a description of his establishment and methods will, I think, prove interesting and serve as a guide to those who may have similar undertakings in view. In passing I may remark that I have known Mr. Hattori these twenty years and have spent a number of summers on his original farm, collecting, with his kind consent, ample materials for my studies on the development of Chelonia. In return, Mr. Hattori is kind enough to say some of the facts and suggestions I have been able to give him, based on my embryological studies, have been of service in carrying out improvements.

The Hattori family has lived a long time in Fukagawa, a suburb of Tokyo, which lies on the "Surrey" side of the Sumida River, and which, having been originally reclaimed from the sea, is low and full

* This chapter is reprinted from a Bulletin of the U. S. Bureau of Fisheries for 1904, Vol. XXIV, pp. 260–266. This industry has reached an advanced stage in certain sections of Japan and has proved to be commercially successful. For this reason this chapter is reprinted in full in this report as it cannot help but be of a great deal of interest and value to those who are contemplating the cultivation of the terrapin, or who are interested in the advancement of this industry in North Carolina.

of lumber ponds* and until recently paddy fields. The occupation of the family was that of collecting and selling river fishes such as the carp, the eel, and the crucian carp, and of raising gold-fishes, in addition to the ordinary farmer's work. As far back as in the forties of the last century, the high price commanded by the "suppon" seems to have suggested to the father and the uncle of the present Hattori the desirability of cultivating it, and this idea, once started, seems never to have been lost sight of, although lying in abeyance for a long time.

In 1866 the first large turtle was caught, and from then on additions were made by purchase from time to time, so that in 1868 there were fifteen, and by 1874 the number reached fifty, which were all very healthy, with a good admixture of males and females. In 1875 these were placed in a small pond of 36 tsubos†, with an island in the center, which was intended for the turtles to lay eggs on. They, however, seemed to prefer for this purpose the space between the water-edge and the outer inclosure; hence, to suit the tastes of the reptile, the pond was hastily modified into a form very much like the one in use at the present day. That year over one hundred young were hatched, but, unfortunately, they were allowed to enter the pond in which the adults lived, and all but twenty-three of them were devoured, making it evident that some means were necessary to protect them from their unnatural parents. Thus was gradually evolved the present system of cultivation.

DESCRIPTION OF TURTLE FARM.

In general appearance a turtle farm is at a first glance nothing but a number of rectangular ponds, large and small, the large ones having a size of several thousand tsubos. The ponds are undergoing constant modification, being united or separated just as need arises, so that their number may vary considerably at different times. Fig. 1 gives the plan of the Hattori turtle farm at Fukagawa as at present laid out. There pass through the farm two small canals which communicate on the one hand with the river across the road, and on the other with the ponds, so that the water can be drawn into, or emptied from, each of them at will.

* Ponds in which lumber is kept soaked in water.

† One tsubo, an area 6 feet square, is the unit in the measurement of small land surfaces.

All ponds, whether large or small, are constructed very much on the same plan. They are limited on their four sides by plank walls, the top of which may either be on the level of the ground (see the right side of the section, fig. 2) or may be more than a foot above the ground when two ponds are contiguous (the left side, fig. 2). In either case the plank wall has a cross plank of some width at right angles to it on its top, and is also buried some inches in the ground. The former arrangement is, of course, to prevent the tortoises from climbing over the wall, and the latter to prevent them from digging holes in the ground and making their escape in that way, while at the

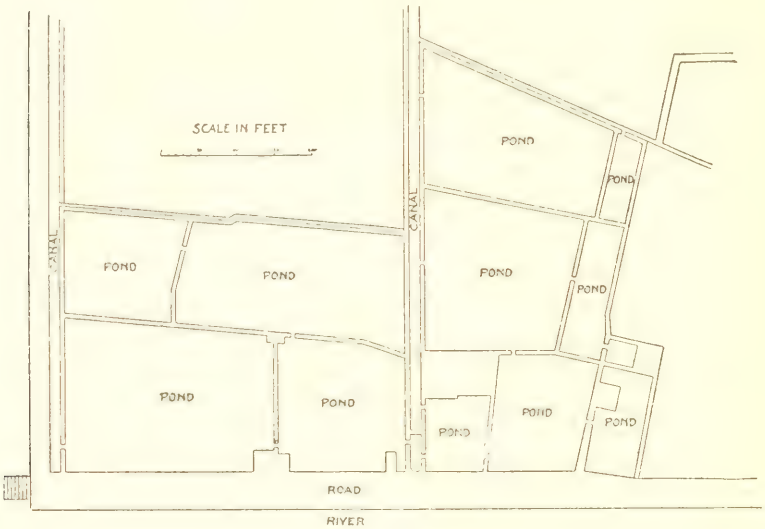


FIG. 1—Plan of a Turtle Farm in Japan.

same time it serves to exclude the moles. On the inner side of the plank wall there is more or less of a level space, and then a downward incline of 3 or 4 feet. At the foot of this incline and directly around the water's edge there is another level space which enables people to walk around the pond. From the edge of the water the bottom of the pond deepens rather rapidly for a space of some 3 feet and there reaches the general level of the bottom, which is about 2 feet below the level of the water. The greatest depth of a pond is about 3 feet and is always toward the water-gate by which the pond communi-

cates with the canals. The bottom is of soft, dark mud, several inches thick, into which the tortoises are able to retire to pass the winter.

On a turtle farm one or more of the ponds is always reserved for large breeding individuals, or "parents," as they are called. The just-hatched young or the first-year ones must have ponds of their own, as must also the second-year ones; those of the third, fourth, and fifth years may be more or less mixed.

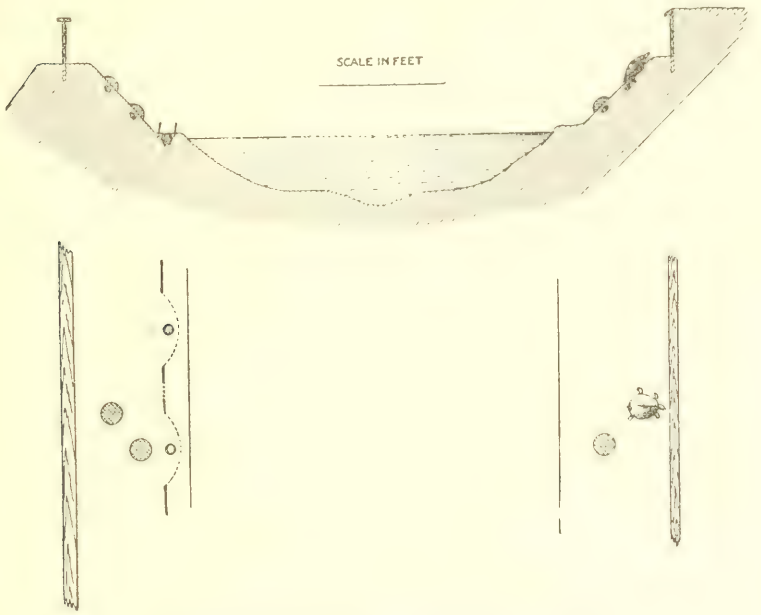


FIG. 2—Section and Plan of a Turtle Pond in Japan.

In order to give a connected account of the raising of tortoises, we might begin with a description of the pond for large breeding individuals, or "parents," and with an account of egg-laying and hatching.

The "parents' pond" does not differ in any remarkable way from the general plan of a pond given above. Usually one of the largest ponds is chosen, and it can be distinguished from the others, because one or two of its slopes are usually kept up very carefully, while the other slopes or those of other ponds are apt to be worn by rain and wind and to become rugged. These well-kept slopes are invariably on the warmer sides, where the sun pours down its midsummer rays longest, and are carefully worked over in the spring so that the tor-

toises will find it easy to dig holes in them. In the breeding season these sides are seen to be covered with wire baskets which mark the places where the eggs have been laid.

LAYING AND NESTING HABITS OF TURTLES KEPT IN CONFINEMENT.

Copulation takes place on the surface of the water in the spring. Egg deposition begins in the last part of May and continues up to the middle of August. Each female lays during that time 2 to 4 deposits, the number differing with individuals and with years.* The process of egg deposition is very interesting. A female comes out of the water and wanders about a little while on the banks of the pond in search of a suitable locality in which to deposit eggs. Having finally chosen a spot, with her head directed up the bank she firmly implants her outstretched forefeet on the earth, and during the whole operation never removes these. The process of egg deposition, which takes altogether about 20 minutes, may be divided into three portions occupying about the same length of time, namely: (1) digging a hole, (2) dropping eggs in it, and (3) closing the hole. The digging of the hole is done entirely with the hind legs. Each with its nails outstretched is moved firmly from side to side—that is, the right foot from right to left and the left from left to right, and the two are worked in a regular alternation, while the body is swayed a little from side to side, accompanying the motion of the legs. The force put in the lateral pressure of the feet is so strong that the earth that has been dug out is sometimes thrown off to a distance of 10 feet or more, although the largest part of it is heaped up around the hole. Digging seems to be continued as long as there is any earth within the reach of the legs to be brought up. The result is a squarish hole with the angles rounded off, and although its size differs with the size of the female, it is generally about 3 to 4 inches across at the entrance, with the depth and width inside about 4 inches or more. When digging is finished eggs are dropped from the cloaca into the hole, which naturally lies just below it. The eggs are heaped up without any order, but, there being no chalazæ, the yolk is able to rotate in any direction, and the blastoderm, having the least specific gravity, always occupies the highest spot of the yolk in whatever position the egg may happen to be dropped. The eggs are generally spherical in shape, although

* See my notes: "How many times does the snapping-turtle lay eggs in one season?" Zoological Magazine, Vol. VII, p. 143, 1895. Tokyo.

A, EGG DEPOSITS OF TRIONYX COVERED WITH WIRE BASKETS.

B, ARRANGEMENT FOR COLLECTING YOUNG TURTLES JUST HATCHED.

sometimes more or less oblate. Their diameter is in the neighborhood of 20 millimeters, the largest being as large as 24 millimeters, the others smaller according to the size of the females. The number of eggs in one deposit varies from 17 or 18 up to 28 or more, the smaller individuals producing the smaller number.

When the eggs have all been deposited, the turtle's legs are again put in requisition, this time to fill up the hole, which is done by alternate motions as before. The earth about the hole is used at first, but search is made for more loose earth for a little distance, as far around as the legs can reach with a slight motion of the body either to the right or left without moving the front legs. Toward the end of the process the loose earth is trampled down. When the hole is well filled up to the level of the ground, the turtle turns around and goes immediately down into the water, not casting even one backward glance.

I have noticed an interesting contrast between the behavior of *Trionyx* and of *Clemmys* during the egg deposition. If one wants to watch a *Trionyx* depositing eggs, one has to crawl on all fours behind the plank wall of the pond and peep through a hole, being careful not to show himself. The moment the snapping-turtle sees any one, it stops in whatever part of the egg-laying process it may be engaged and plunges straight into the water. Utterly different is the behavior of *Clemmys*. When once it begins the process of egg-laying it is never deterred from carrying it out, no matter how near or how boldly one may approach. Whenever I watched *Clemmys* working away in the direct midsummer rays with its carapace all dried up and with its eyes alone moist, I could not help comparing it to a slave of duty fulfilling his fate with tears in his eyes. What causes such a difference of behavior in the two species? What is its significance? What difference in the nervous system corresponds to it?

The traces of a spot where the snapping-turtle has laid eggs are (1) the two marks made by the forepaws holding on to the earth during the whole operation, and (2) a disturbed place some distance back of the line of the forepaws where the hole has been made. The three marks are at the angles of a triangle. I have noticed a very interesting fact in regard to these traces. When a young female is depositing her first eggs, she is very clumsy, the hole being badly made and the filling in of it very imperfect, so that often a part of it remains open. Old females are extremely neat in their doings, and one can determine at once the age and size of the female by the skill

displayed and by the distance between the three marks of egg deposition. This shows that although the elaborate actions necessary in egg-laying must be, in the main, due to instinct, each individual has to add its own experience to the inherited impulses and is able thus only to accomplish the desired end with perfection.

In Hattori's farm a person goes around the "parents' pond" once a day or so and covers up with wire baskets all the new deposits made since the last visit (Pl. XVI, A). Each basket may be marked with the date if necessary. This covering serves a twofold purpose—the obvious one of marking the place, and in addition that of keeping other females from digging in the same spot. When hundreds, or even thousands, of these baskets are seen along the bank of a "parents' pond," it is a sight to gladden the heart of an embryologist, to say nothing of that of the proprietor.

The hatching of the eggs takes, on an average, 60 days. The time may be considerably shortened or lengthened, according to whether the summer is hot and the sun pours down its strong rays day after day, or whether there is much rain and the heat not great. It may become less than 40 days or more than 80 days. By the time the last deposits of eggs are made in the middle of August, the early ones, which were laid in May or June, are ready to hatch; and inasmuch as if small tortoises that have just emerged from the eggs are allowed to get into the "parents' pond" they are devoured by their unnatural fathers and mothers, a special arrangement has now to be put up to prevent this. Plate XVI, B, and the left side of the plan in fig. 2 are intended to show this arrangement. Long planks about 8 inches wide are put up lengthwise around the edge of the pond, leaving perhaps 1 foot margin between them and the water. Two successive planks are not placed contiguous, but a space of about 3 feet is left between every two, and closed by a bamboo screen put up in the shape of an arc of a circle, with its convexity toward the pond. Thus the slope or the bank where the eggs have been deposited is completely cut off from the pond itself. In the center of every pocket-like arched space made by a bamboo screen an earthenware jar is placed with its top on the level of the ground, and some water is put in it. This elaborate arrangement is for the reception of the young tortoises, which, as soon as they break through the egg-shells—those belonging to the same deposit generally coming out at the same time—crawl up to the surface of the ground by a hole or holes made by themselves, and

go straight down the incline toward the pond, as naturally as the duckling takes to the water. They are stopped, however, in their downward hydrotaxic course by the planks put up, as stated before, around the pond, and they crawl along the length of the planks and sooner or later drop into the jars placed in the recesses between every two planks. A man going around once or twice a day can easily collect from these jars all the young hatched since the last visit.

CARE OF YOUNG TURTLES.

The young just hatched are put in a pond or ponds by themselves and given finely-chopped meat of a fish like the pilchard. This is continued through September. In October *Trionyx* ceases to take food, and finally burrows into the muddy bottom of the pond to hibernate, coming out only in April or May. The young are called the first-year ones until they come out of their winter sleep, when they are called the second-year young. At first the same kind of food is given these as that given to the first-year young, but gradually this may be replaced by that given to older individuals, namely, any fish, meat or crushed bivalves, etc. From the third to the fifth year, inclusive, the young need not be kept in ponds strictly according to age, but may be more or less mixed, if necessary. The young of these years are also the best and most delicate for eating and are the ones most sold in the market. In the sixth year they reach maturity and may begin to deposit eggs, although not fully vigorous till two or three years later. How old these snapping-turtles live to be is not known. Those 1 foot and more in length of carapace must be many years old. The following table gives the average size of the carapace and the weight of the young:

Age.	Length in centimeters.	Breadth in centimeters.	Weight in grams.
Just hatched	2.7	2.5	
First year	4.5	4.2	23
Second year	10.5	8.8	169
Third year	12.5	10.5	300
Fourth year	16.0	13.5	563
Fifth year	17.5	15.1	750

One of the most important questions in turtle-farming is that of food supply. The profit depends largely on whether a constant sup-

ply of healthful food can be obtained cheaply and abundantly. In the Hattori farm chief dependence in this respect is laid on the "shiofuki" shell (*Mactra veneriformis* Deshayes) which occurs in enormous quantities in the Bay of Tokyo. These shells are crushed under a heavy millstone rolled in a long groove in which they are placed. Other kinds of food given are any dried fish scraps, silkworm pupæ, boiled wheat grains, etc.

A curious part of the ecological relations of a turtle pond is this: It would be supposed that putting other animals in the same pond with the snapping-turtles would be detrimental to the welfare of the latter, but experience has proved just the contrary. It is now found best to put such fishes as carp and eels in the same ponds with the turtles. The reason, I am told, is that these fishes stir up mud and keep the water of the pond always turbid, and this is essential to the well-being of the turtles, as is proved when the messmates are taken out of the pond. Dirt and mud then settling down, and the water becoming clear and transparent, the turtles, which are extremely timid, will not go about searching for food, and thus very undesirable results are brought about.

SUMMARY.

The business of turtle-raising has thrived well. When I first became acquainted with the turtle farm, now over twenty years ago, it was a small affair with only a few small ponds, and the eggs hatched out in one year were, all told, not much over 1,000. Now the enterprise embraces three establishments: (1) The original farm at Fukagawa, Tokyo, now enlarged to 7 acres; (2) the large farm at Maisaka, near Hamamatsu, province of Totomi, over 25 acres, whither the main part of the business has been transferred; and (3) the second farm in Fukagawa, about 2 acres in extent. These three establishments together will yield this year (1904) about 4,100 egg-deposits, which means 82,000 eggs, counting 20 eggs to a deposit on an average. Probably 70,000 young will be hatched from these, and deducting 10 per cent loss before the third year, there will be about 60,000 "suppon" ready for the market in three years. The turtles sold in a year in Osaka, Tokyo, Nagoya, and a few other towns, weigh about 2,000 kwan (= 16,500 pounds), and are worth about 6.50 to 7.50 yen (1 yen = $0.50) per kwan.

There are several minor turtle farms besides those mentioned above, but as they are all modeled after those under Mr. Hattori's management they need not be described further.

CHAPTER VII.

ECONOMIC VALUE OF THE DIAMOND-BACK TERRAPIN.

The following chapter has been prepared in order to call special attention to the economic value of the diamond-back terrapin, the present condition of this industry, and its future prospects. Information regarding these points has been obtained chiefly from market-men, shippers, and fishermen with whom the author has had an opportunity to talk at various times.

MARKET VALUE OF THE TERRAPIN.

The diamond-back terrapin owes its importance as a food product not to its abundance, but to the exceptionally fine quality of its meat. Holding, as it does, an almost unrivaled position as a fancy food article, its increasing scarcity in the regions most favorable for its growth has caused it to become probably the highest-priced food product of the coast waters.* Formerly the very high prices were paid only for terrapins from the Delaware and Chesapeake bays and other northern waters. As the form became scarcer in these bays, shippers of Chesapeake terrapins replenished their stock with terrapins from North Carolina waters. Sometimes these were kept for a short time in pounds on the Chesapeake Bay; then were mixed with native terrapins and shipped to the northern markets as true "Chesapeake" terrapins. It is certain, too, that some South Carolina terrapins were brought into North Carolina to be shipped with terrapins of the latter State to the Chesapeake and thence to the city markets. In time, however, it was learned that many of the North Carolina diamond-backs were scarcely, if at all, inferior to the more northern terrapins, and it became less and less necessary to allow a middle profit to the Chesapeake dealer. At the present time probably very few North Carolina terrapins are shipped to the city wholesale

* Six-inch terrapins bring, at wholesale, $30 to $36 per dozen. Seven-inch terrapins may bring $60 or more per dozen. I have been informed (by the sellers) of two sales, each of one dozen eight-inch terrapins. It is doubtful if there have been other sales of as many of this rare size at one time. In one case $96 was received for the dozen, and in the other $120. According to market-men, frequently one or two selected terrapins are bought at retail at the latter rate or higher. The length is measured on the bottom shell. The larger terrapins are all females or "hens." The males or "bulls" are rarely much over 4 inches in length. After many inquiries I have *heard* of one male that measured 5 inches, and of one female that measured as high as 9¼ inches. "Bulls" are usually quoted at about $12 per dozen. Many undersized females are probably included as "bulls."

markets as "Chesapeakes," although they may be sold as such to the consumer. Probably the great majority of South Carolina diamond-backs were formerly, as now, shipped to the markets direct from Charleston and other points in the State; but it appears that they command a somewhat lower price than what is paid for those from North Carolina, which is in turn, on the whole, lower than that paid for Chesapeakes. Quite recently the Gulf States have entered the market—at first, as seems quite certain, in an indirect way. That is, their terrapins were first shipped to Maryland and Virginia dealers and resold then by them to the market-men of Baltimore, New York, and other cities.

Thus, while the highest prices are still paid for "Chesapeakes," real or supposed, and in a somewhat less degree for terrapins from North Carolina, the rise in price has been checked by the increasing willingness of consumers to accept at a lower price the forms from more southern waters. This is a fact of some practical importance, for if it is found that breeding and growing terrapins for market does not present too great practical difficulties, the prospective dealer will be interested in the question of how far the advance in prices that has continued for many years may be expected to continue.

It seems certain that the demand for terrapin is a permanent one, based on the quality of the meat and the willingness of those who can afford it to pay the necessary price; and with the increase in population and in wealth, the demand will not lessen, but will grow. If, however, a steadily increasing proportion of the consumers is content with the terrapins from the rich waters of more southern States, or with other species of turtle, prices may not be expected to rise in the near future. In fact, it would seem that prices reached their high-water mark more than five years ago, and that since that time there has been no permanent advance.

On the contrary, greater and greater inroads into the market have been made by southern diamond-backs, and more and more of the demand has been diverted to fresh-water terrapins, such as the various "sliders" and the "Western Golden Stripe," species of *Pseudemys* and *Graptemys*, etc. In time, of course, if in the fisheries of southern waters and in the fresh-water fisheries there prevails the same short-sightedness that has caused the gradual exhaustion of more northern waters, approximate extermination must ensue there as elsewhere; and then, if tastes do not change, prices may go yet higher.

RELATIVE FOOD VALUE.

In discussing the relative value of terrapins from different States, we have referred not to relative food values, but to market values. The terrapin market is distinctly a "fancy" market, and in it certain types of terrapin rank higher than others. How far this ranking is based on actual differences in quality, it would be difficult to say. On the one hand, it is certain that the market estimate has undergone modification in recent years, and it has been discovered that southern forms are better than was supposed. On the other hand, it is quite possible, perhaps probable, that the differences in environmental conditions in different regions are fully adequate to produce distinct differences in the quality of the meat. In fact, such structural differences are distinguishable as have made necessary the breaking up (by Professor Hay) of what was originally regarded as one species into several geographic species and subspecies. We have a Texas species, a Louisiana species, a Florida species, a Carolina species and a Chesapeake subspecies of the latter.

The market also recognizes distinct types, but the classification most generally used among market-men is the gross one of "Chesapeakes" and "Southerns." The "Chesapeake" type can hardly be distinguished with certainty except by an expert market-man; but, generally speaking, it may be said to be characterized by a smaller head, deeper body, more clearly marked rings of growth, and a carapace that flares posteriorly. Compare Pl. II, A and B. One who talks with market-men and examines terrapins in the market or in the field becomes convinced that not all "Chesapeakes" in market terminology come originally from the Chesapeake Bay.

Even in North Carolina terrapins from one locality look better than those from another. The diamond-backs from Core Sound seem to present a better appearance than those from Beaufort Harbor. Some of the most highly valued terrapins of the State are found about Hyde County and neighboring shores; but I have been informed by a leading dealer in the Baltimore market that he sometimes receives from Wilmington and elsewhere terrapins that are quite indistinguishable from "Chesapeakes," and that the resemblance in character and quality of meat is equally close. Without careful study of this particular point it cannot be stated just what is the relative

proportion of the two types in North Carolina, nor in what localities nor under what environmental conditions the more desirable forms are to be found. Undoubtedly, however, the "Southern" form predominates in North Carolina.

Although terrapins are much more abundant toward the south, the larger sizes, such as 7-inch terrapins (length of bottom shell), are relatively much less abundant.

THE TERRAPIN INDUSTRY IN NORTH CAROLINA.

The scarcity of the diamond-back in the State is directly attributable to the short-sighted methods of fishery employed. Formerly they were very abundant. Many more or less reliable stories are told of its abundance. According to one that is believed to be authentic, these terrapins were once an occasion of much annoyance in the Stumpy Point Bay region, it being sometimes necessary to lose a haul of fish because the quantity of terrapins unavoidably taken when hauling a net near the marshes prevented the drawing in of the net. Fifty years ago, when the fishery products of Carteret County were either used only for home consumption or else almost entirely neglected, terrapins were bought for seventy-five cents per dozen.

It seems to have been in the late sixties that shipping to northern markets began. At first the prices were quite small as compared to present prices—about $3.00 per dozen for 5-inch terrapins or "half-counts," and $6.00 per dozen for 6-inch or "full-counts," in market terminology. Steadily the price rose until a few years ago 6-inch terrapins shipped from Beaufort brought $15.00 in summer to $24.00 per dozen in winter. Now, in winter, the only season in which they are shipped, that size may bring $30.00 to $36.00, the highest prices ordinarily paid for this size. Probably the greater part of the terrapins shipped are undersized and sell at very much lower prices.

We have but few figures regarding the extent of this fishery in North Carolina, but from inquiries made in 1902 of dealers in Beaufort, Morehead City, and Marshallburg, it is believed that the shipments from these three points during the preceding season (1901-'02) would not far exceed 3,000 of all sizes. Terrapins are also shipped from Wilmington, New Bern, Washington, Bell Haven, Stumpy Point, Manteo, and other points.

In the following table there is given the yield of the terrapin fishery of North Carolina in 1897 and in 1902, as given in the U. S. Fish Commission Report for 1897 and 1902, respectively:

County.	1897.			1902.		
	Pounds.	Number.	Value.	Pounds.	Number.	Value.
Beaufort			$	1,000		$ 400
Brunswick	4,500		630	4,800		1,060
Carteret	6,428		1,000	1,660		1,060
Dare	6,251		1,185	7,472		4,140
Halifax				433		260
New Hanover				1,500		450
Onslow				3,500		1,100
Pamlico				480		265
Pasquotank				2,935		147
Pender				7,000		2,160
Total	17,179	8,160	2,815	30,780	15,390	11,042

These figures show that the yield of terrapin has increased from 8,160 in 1897 to 15,390 in 1902, and that this increase has been brought about by the extension of the fishery from 3 counties in 1897 to 10 in 1902. The number taken in Carteret County in 1902 is about one-fourth that taken five years earlier. Dare and Brunswick have each increased their apparent yield, but Dare draws largely from Hyde County (not credited), and it is practically certain that Brunswick fishermen bring terrapins from South Carolina.

While the number credited to the 10 counties in 1902 is 89 per cent greater than the number credited to 3 counties in 1897, the value of the terrapin to the fishermen is greater by 292 per cent. Had the 15,000 terrapin taken in 1902 been of full size, the value should have been twofold greater.

The average price received by fishermen has more than doubled in the five years from 1897 to 1902, but this price at the latter time is only 72 cents. This shows in a striking way that the great majority of the terrapins marketed are undersized, and that the result to the State is a proportionate loss.

Generally speaking, the average price is found to be higher for the northern and middle counties, such as Dare and Carteret, than for the southern counties, as Onslow, Pender, and Brunswick.

Although the terrapin fishery of this State is not now an extensive industry, it is worthy of note that whatever the returns from it may amount to, they are practically so much clear profit. No outlay is required for special boats or nets. Even where pens are used, little attention is given them (too little!) and almost no expense is incurred. In some places fishermen may devote their time for a few days to hunting terrapins, but about Beaufort, at any rate, the great majority are taken by chance, while searching for fish or shell-fish. The chance specimen is taken home and sold to some fish-dealer, who puts it aside until a sufficient number have accumulated to justify a shipment. The term "industry" as applied to the collecting and shipping of terrapins is almost a misnomer.

The high market value of the form, with the fact that its generous yield is almost without cost to the beneficiaries, makes the form of peculiar interest to the State, and it is important that we should consider the outlook for this fishery and whether or not any measures may be taken for its preservation and development.

THE OUTLOOK FOR THE TERRAPIN INDUSTRY.

The former abundance of the terrapin in North Carolina waters and its present scarcity have already been discussed. This scarcity makes the outlook for the future particularly serious, for two reasons:

1. The terrapin has not the power to regain its hold within a few years, as the oyster or the clam might do. Each female lays but a few eggs and the young that hatch from them undergo many perils. Those that survive the dangers of early life are slow to reach the stage where they may start another generation, and before reaching this stage they may be captured and sold at a small price.

2. The terrapin gets no opportunity to re-establish itself. Though they are now so scarce that it rarely pays to hunt them, yet the market value is such that no chance individual observed will be passed by. In the exhaustive search of our waters for clams, oysters, crabs, and fish, individuals are not infrequently found, and thus the work of extermination proceeds without check. Exhaustion of the fishery is inevitable, unless some legislative provision be made for its preservation.

Only two methods of protection suggest themselves. The one is propagation; the other, effective restriction of the fishery.

In regard to the first method, it is impossible at this time to say whether or not breeding of terrapins will become generally practicable. Thus far no business venture in this direction has been entirely successful. The chief stumbling-blocks seem to have been:

1. The failure to get terrapins to breed satisfactorily in the close confinement usually offered.

2. The want of knowledge of the habits of the young and the conditions necessary for their development.

The experiments of the Bureau of Fisheries have removed some of the difficulties, but until the experiments have reached a further stage, a decision cannot be rendered as to the practicability of propagation. We may, therefore, say that the only present visible hope for the preservation of the terrapin fishery lies in the restriction of the fishery.

LEGISLATION RELATING TO TERRAPIN INDUSTRY.

The present laws of the State for the protection of the terrapin industry as given in the Revisal of 1905 of the Laws of North Carolina are as follows:

2369. Use of Drag-nets by Non-residents for Catching Terrapins Forbidden.—If any person who is not a citizen and who has not resided in the State continuously for the preceding two years shall use any drag-net or other instrument for catching terrapin he shall be guilty of a misdemeanor.

Code, ss. 3375, 3376.

2370. Diamond-back Terrapin Protected.—If any person shall take or catch any diamond-back terrapin between the fifteenth day of April and the fifteenth day of August of any year, or any diamond-back terrapin at any time of less size than five inches in length upon the bottom shell, or shall interfere with, or in any manner destroy any eggs of the diamond-back terrapin, he shall be guilty of a misdemeanor, and shall be fined not less than five dollars nor more than ten dollars for each and every diamond-back terrapin so taken or caught, and a like sum for each and every egg interfered with or destroyed: *Provided*, this section shall not apply to parties empowered by the State to propagate the said diamond-back terrapin; and the possession of any diamond-back terrapin between the fifteenth days of April and August shall be *prima facie* evidence that the person having the same has violated this section. It shall be the duty of

all sheriffs and constables to give immediate information to some justice of the peace of any violation of this section.

Code, s. 3377; 1899, c. 582; 1881, c. 115, ss. 1, 6.

The provisions of this law are very good, and had they been even reasonably well enforced, the terrapins would now be far more abundant and more valuable to the State. By way of improvement, the closed season could well be lengthened. As the selling season in the markets of the larger cities closes by law at an earlier date, the terrapins captured late in March or in April will either be sold for a very small price or will be penned until the next fall. In the latter event, the young that might have been produced in summer are lost to the future of the species. Furthermore, as we have seen, terrapins may come from hibernation early in March, and mating probably takes place very soon after coming out. It is strongly advisable to leave them undisturbed during this period, when they are doubtless more easily taken than at other times. A closed season of six (6) months may be recommended to begin March 1st and close August 31st.

The most serious defect of the present law is that it is absolutely unenforced. It will be no gain to lengthen the closed season if adequate provision be not made for the strict enforcement of the provisions of the law. This problem of enforcement of the terrapin law is peculiarly difficult, as a terrapin worth over a dollar to the fisherman and twice as much to the shipper may be carried in the pocket, and several hundred dollars worth of terrapins would hardly cover the bottom of a hogshead. The conditions may thus be summed up as follows:

1. The present law is ignored. It is extremely doubtful if a single terrapin taken at any time is ever discarded unless so small as to be valueless.

2. Almost every violator is in favor of the enforcement of the law, provided it be enforced against all.

3. Only a most rigid enforcement will accomplish anything. It is peculiarly easy to conceal violations of laws restricting the capture of terrapins.

4. The future of the terrapin fishery in the light of present information is absolutely conditioned on effective State protection.

Given these conditions, what measures can be taken to relieve them? One or two suggestions may be made.

The enforcement of the terrapin laws may be assigned to some officer who shall be responsible for the enforcement of said laws. It would not be necessary to have a special officer for the terrapin, but this duty could be assigned to a commission which should be charged with the enforcement of all the fishery laws, except such as are now assigned to the Oyster Commission.

Another possible provision presents some objections, but is a feature of the Baltimore law and seems to be approved by market-men, not because of its inherent qualities, but because it accomplishes the desired end as nothing else would do. This is a provision that one-half of the fines shall go to the informer. Such a provision has been used in North Carolina, being included in Chapter 164, Laws of 1889, by which section 3377 of The Code of 1883 was re-enacted for Brunswick County.

Further strength might be given the law by making it illegal for any person or company to receive or have for transportation undersized terrapins; also by making the possession of eggs or of undersized terrapins, or of any terrapins during the closed season, *illegal*, instead of, as now, "*prima facie* evidence of violation of the law."

SUMMARY.

The southern terrapins have in recent years attained a much higher relative value in the city markets, and this applies particularly to diamond-backs from North Carolina. This form was once quite abundant in this State, but is now approaching extermination. Although terrapins are too scarce to be hunted except in rare instances, the work of exhaustion proceeds without check, as every chance specimen is marketed.

The only visible hope for the industry lies in the restriction of the fishery.

The present laws are absolutely ignored.

It is recommended that the present laws be modified by extending the closed season to six months (March 1st to August 31st), by making it "illegal" (1) to have a terrapin in possession during the closed season; (2) to have undersized terrapins at any season; (3) or to receive or have in charge for transportation or for any other purpose undersized terrapins.

Improvement of the law is useless unless adequate provision be made for rigid enforcement.

CHAPTER VIII.

OTHER FORMS OF TURTLES (CHELONIA) AT BEAUFORT, N. C.

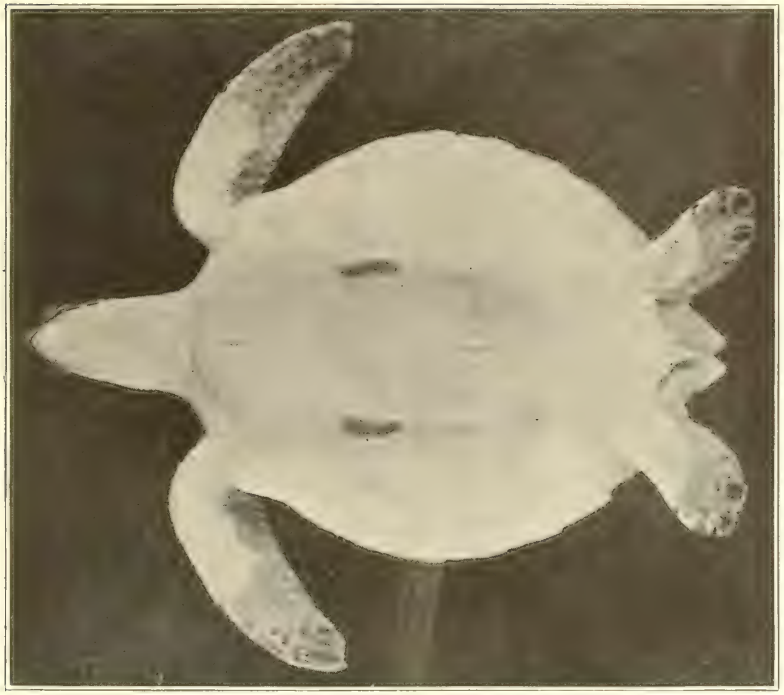
DERMOCHELYS CORIACEA, OR TRUCK-BACK TURTLE.

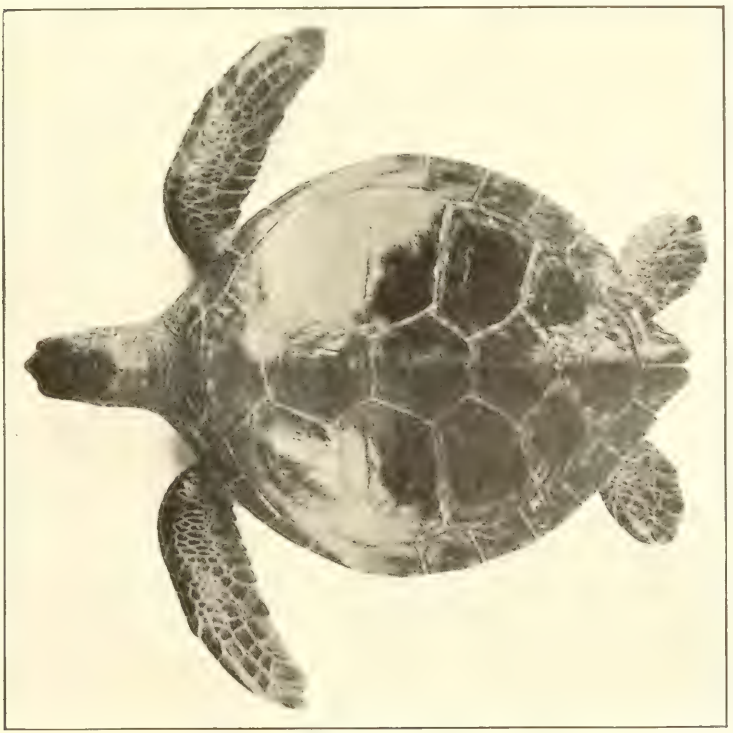
The species *Dermochelys coriacea* (Vandelli), commonly known as the truck-back or leather turtle, is the only turtle included in this list of which the writer has not collected or seen a specimen at Beaufort. Occasional specimens are known to have been taken, especially in former years when the large nets were used at Cape Lookout. Mr. H. H. Brimley, Curator of the State Museum, states that a specimen in the Museum at Raleigh, captured near Beaufort on May 27, 1897, weighed about 800 pounds.

CHELONE MYDAS (L.), OR GREEN TURTLE.

This turtle, known locally as "green turtle" or "chicken turtle" (when young) and ranking next in value to the "tortoise-shell turtle" or (proper) hawksbill turtle, was common at Beaufort in former years, but its visits have become less and less frequent until now the capture of a green turtle near Beaufort is a rare occurrence. Only one has been obtained by the Laboratory; a small specimen being taken by hand in a "creek" in the marshes of Newport River near Harlow Creek, July 6, 1905. Mr. J. H. Potter advises me that the last specimen he has seen or shipped was in the late summer of 1902 (weight 55 pounds), but that in former times they were sometimes shipped by the barrel, and it was seldom difficult in summer to obtain them. It is said that the best place to find them inside the harbor was between the Middle Marshes and Bottle Run Point of Shackleford Banks, but that the largest catches were made at the Cape, where one hundred were sometimes taken at a time, to be sold to shippers at about 15 cents each. The meat has now a market value of about 15 to 25 cents or more per pound. The exhaustive fishery in more southern waters and the despoiling of the nests for the eggs doubtless accounts for their present scarcity.

The young of this turtle are called, locally, "chicken-turtles," and the great majority of those taken at Beaufort were young forms. I





A AND B, A YOUNG SPECIMEN OF GREEN TURTLE. LENGTH OF CARAPACE 13 INCHES.

am indebted to Mr. J. H. Potter for information that the two largest specimens obtained by him weighed, respectively, 150 and 80 pounds.

The specimen brought to the Laboratory, an immature female, is shown in Pl. XVII, A and B. While kept in an aquarium at the Laboratory for more than a month, it was fed chiefly on fiddler-crabs. The measurements (using tapeline and following curvature of shell) were:

MEASUREMENTS OF GREEN TURTLE.

Length of carapace	13 inches (12.6).*
Greatest breadth between margins—	
Measured over carapace	11.1 inches (10.5).*
Measured under plastron	11.9 inches.
Length of plastron	10.5 inches.
Length of head from tip of snout to posterior end of supraoccipital	3.3 inches.
Breadth of head	2.1 inches.

The shell, head and flippers of this turtle are in the museum of the Laboratory at Beaufort, N. C.

KEMP'S GULF TURTLE, THALASSOCHELYS, COLPOCHELYS, KEMPII (GARMAN).

At the present time the most abundant marine turtles at Beaufort are the loggerhead sea-turtle and Kemp's Gulf turtle. The latter is known locally as the Hawksbill, which, however, is an unfortunate designation, since this name is generally applied to the tortoise-shell turtle [*Eretmochelys imbricata* (L.)]. This local misnomer for Kemp's Gulf turtle is probably the basis for the undoubted error of some writers of including North Carolina within the range of *Eretmochelys*. Kemp's turtle is common about Beaufort and doubtless along the whole Atlantic coast, but has received almost no attention from herpetologists, even escaping Holbrook's notice.

This species (Kemp's Gulf turtle) was described by Garman in 1880† from "a pair of fine specimens" furnished by Richard M. Kemp of Florida. Baur, in 1886, published a few osteological notes on these specimens and one other.‡ I know of no other descriptive

* The two measurements in parentheses were taken with calipers.

† Samuel Garman, "On Certain Species of Chelonicidæ," bulletin of Museum of Comparative Zoology, Vol. VI, No. 6, Cambridge, 1880, pp. 123-4.

‡ Baur, G., "Osteologische Notizen uber Reptilien," Anat., Aug., 1888, pp. 423-4.

notes of this turtle, and the photographs here reproduced (Pl. XVIII, A and B) are believed to be the first figures of the turtle published. In connection with these figures it may be well to give a brief description of the turtle. Garman makes no reference to color and does not take account of the possible variability of the turtle in some important points. The description which follows, while based on Garman's account, is supplemented from observation of Beaufort specimens.

The body is depressed, short, broad, subcircular, with a slight concavity over the lateral marginal plates of the carapace and without the prominent rounded hump on the vertebral series over the pelvis or shoulder girdle, as in *T. caouana* (*T. caretta*). Head is intermediate in size between that of *T. caouana* and that of *Chelonia mydas*, and the crown is slightly convex. Looking from above, the outline of the face is much more convex than in either of the species cited.

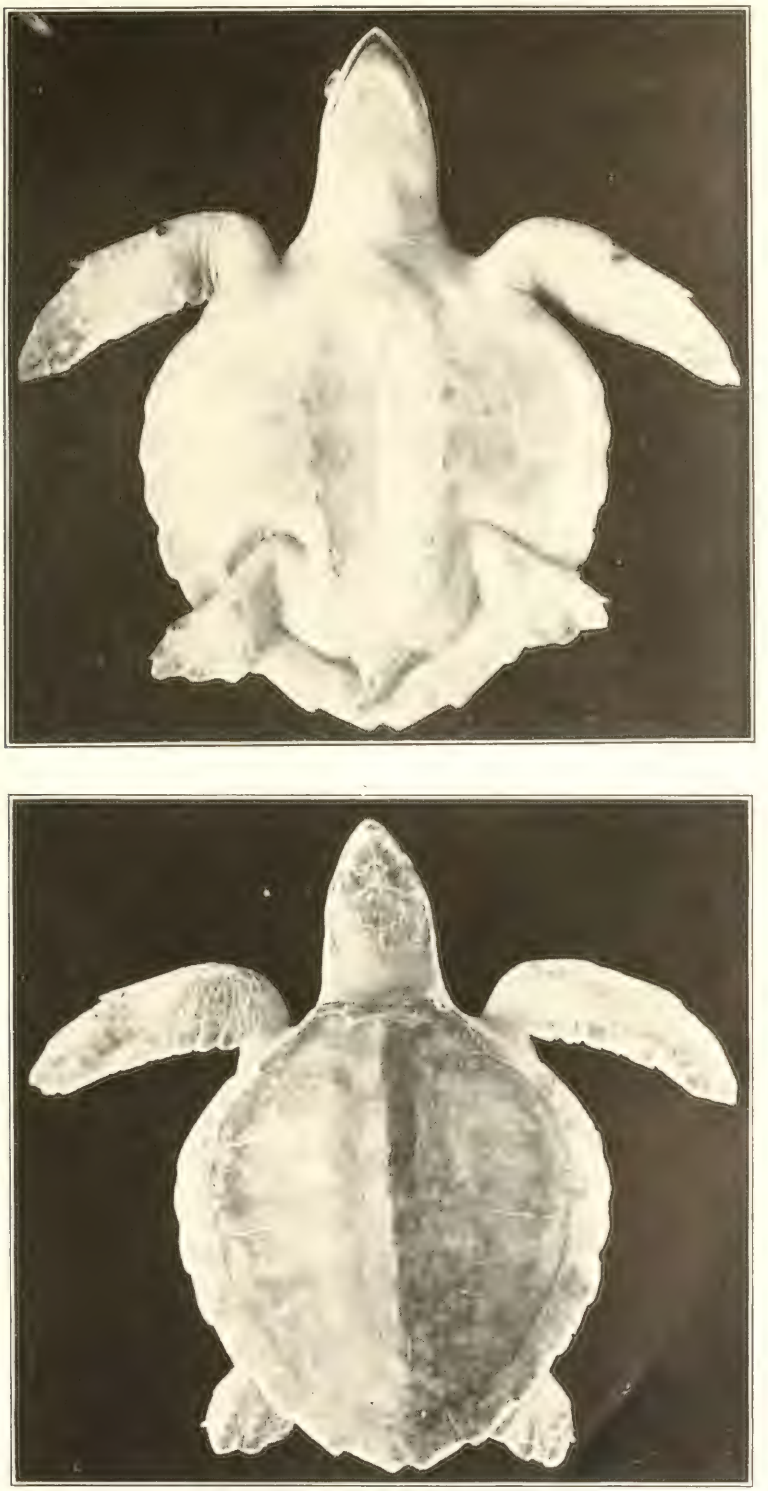
Jaws are without serrations; lower outlines of upper jaw forming a sigmoid curve descending to a sharp point at the symphysis, upper edge of lower jaw concave, curving upward to a point at the symphysis. (The shape of the jaws gives rise to the local name "Hawksbill").

The horny scutes of the carapace are somewhat variable in number and shape, as is the case with *T. caretta;* but the following description will be approximately correct:

The *nuchal* is very short and wide, hexagonal and shortest in middle; the *vertebrals* are narrow, width of first a little greater than length, second and third almost rectangular, fourth narrowing posteriorly; a small "supernumerary" scute may intervene between fourth and fifth (present in two of four shells examined by me); fifth wide and subtriangular, the truncated apex directed anteriorly.

Costals, 5, the anterior small.

Marginals, 26 (exclusive of nuchal); the anterior marginals very narrow, becoming wider from the fourth; eighth to twelfth subequal, the caudal pair wider (antero-posteriorly), the greater width being gained, not by projecting beyond the general outline, but by indenting the base of the last vertebral. In two of my specimens there are 14 marginals on one side; in one of these, 2 scutes of the left side correspond to the single fourth of the right side; in the other, the second, third, and fourth of the left side are represented by 4 scutes on the right.



A AND B. KEMP'S GULF TURTLE. LENGTH OF CARAPACE 12.8 INCHES.

Posterior paddles with 2 nails, anterior with 1, this being the case in my specimens; Garman says "each with two nails." Nails of anterior paddles are doubtless variable with age and individuals. Margins more or less indented between the digits.

The ratio of the measurements of breadth in this turtle when the tapeline lies over the carapace or under the plastron, contrasts significantly with the corresponding ratio in the case of the green turtle. Thus in our specimen of *Chelone* (see above, p. 56), the ventral measurement exceeds the dorsal by 7 per cent, that is, the body is fuller below the margins of the carapace than above; while in two live specimens of *T. kempii* (see below) the reverse is the case, for the dorsal measurements exceed the ventral by 10 and 12 per cent, respectively. The underside is, in fact, almost flat. The median region of plastron arches inwards somewhat from gulars to posterior end.

The upperside is of a rather uniform dark, dull olive color, except that carapace and flippers are margined with yellowish white, especially the anterior margins of flippers. Dorsal side of bases of limbs are more or less greenish white. Underside yellowish or greenish white, except near outer ends of paddles, where a dark mouse-color prevails.

Garman rates some of the distinguishing characters of this turtle as of more than specific importance, and, according them a subgeneric value, proposes the subgenus *Colpochelys*.

The measurements of four specimens with tapeline were as follows:

MEASUREMENTS OF KEMP'S GULF TURTLE.

	1	2	3	4
	Inches.	*Inches.*	*Inches.*	*Inches.*
Length of carapace	15	14.2	13.5	12.8
Greatest breadth measured over carapace	15	14.4	13.5	13.4
Greatest breadth measured under plastron.			12.3	11.9
Length of plastron	11.3	10.5	9.9	9.7
Length of head			4.6	4.5
Breadth of head			3.1	2.8

Measurements of 1 and 2 from preserved shell; 3 and 4 from live specimens. No. 4 represented in photographs, Pl. XVIII, A and B.

It may be noted that the length and breadth (measured over curvature of carapace) are equal, or the breadth a little greater. The measurements of Garman's specimens, both "quite aged," were: (1) Width and length equal, 26 inches; (2) width 29 inches, length 28.

Distribution.—Regarding the distribution of this turtle, Garman merely states, "found in the Gulf of Mexico," and, in a later publication,* "northeastern part of the Gulf of Mexico." Its common occurrence at Beaufort during the warmer months is, therefore, of especial interest.

While the loggerhead sea-turtle lays commonly on the beach near Beaufort, the nests of Kemp's turtle are not known there. Garman quotes from Mr. Kemp: "We know that they come to the beach to lay in the months of December, January, and February." At this season, turtles are, of course, absent from the region of Beaufort.

This habit of laying in winter (if correctly given) makes this turtle quite remarkable among the sea-turtles of this coast. And, since it is worthy of comment that two such closely related species as *kempii* and *caretta* should be practically co-extensive in range, and should breed in the same regions (as the waters of southern Florida), this difference of breeding habit may suggest the possible means of isolation of the two forms in past times.

In Florida, the name "bastard" is applied to Kemp's turtle—"said to be a cross between the green and loggerhead" (Garman).

The turtle has no present market value, though its meat, eaten at Beaufort, is considered much less coarse than that of the loggerhead, and even as good as that of the green turtle. It is not impossible that this species may have a potential economic value. It is hoped that this notice may lead to the gaining of further information regarding the distribution and habits of an interesting but strangely overlooked species.

THE LOGGERHEAD SEA-TURTLE, THALASSOCHELYS CARETTA (L).

The loggerhead sea-turtle (Pl. XIX, fig. 1) is not uncommon at Beaufort and is taken quite frequently in the pound-nets of Pamlico Sound. While it has no market value for shipment, it has a small local value, for the animal is quartered and the meat used as food.

* "Reptiles of Bermuda," Part VI of Vol. I of Bulletin of U. S. N. M., No. 25, 1884, p. 301.

FIG. 1. LOGGERHEAD SEA-TURTLE (THALASSOCHELYS CARETTA (L)).

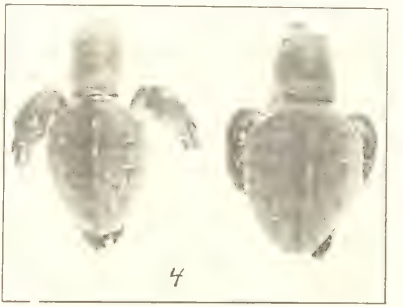


FIG. 2, NEW-BORN LOGGERHEAD SEA-TURTLES. FIG. 3, HEADS OF EMBRYO AND OF 2 NEW-BORN LOGGERHEAD SEA-TURTLES. FIG. 4, EMBRYOS OF LOGGERHEAD SEA-TURTLES.

The loggerhead has, however, an especial interest in view of the fact that the turtles not uncommonly crawl up on the beach along this region of the coast to lay their eggs. Thus, opportunity is afforded for the pursuit of embryological studies or for experiments with the incubation of the eggs of sea-turtles.

Laying Habits.—The laying season, beginning the latter part of May, extends into August.

The nests seem to be made at night, for the sign by which a nest is located is the fresh track found in the early morning leading from the edge of the water to the point where the eggs were laid. Not infrequently the course of the track shows that the turtle returned to the water without depositing eggs, and thus there may or may not be indications that a nest was started. Sometimes, in such cases, another track will be found not far away leading to an actual nest.

Early in the morning the nests are sought by a few fishermen who value the eggs to eat or to sell for that purpose at 5 cents per dozen. A sharp stick is carried with which to probe into suspected places. If the end of the probe, when withdrawn, is smeared with yolk, a nest has been located. Sometimes they are destroyed by hogs; and nests have been found with only fragments of shell and yolk strewn about. During the day the tracks are liable to be obliterated by tide and wind, and sometimes by rain, so that nests that are not found on the following day are usually safe from molestation, at least by man.

Unfortunately, the laying region is not readily accessible from the Laboratory. The nests found were from 5 to 14 miles west of Fort Macon; and, because of this and the conditions mentioned in the preceding paragraph, a collecting trip meant an early morning walk on the beach of 10 or more miles and back. If the trip was successful, 1 or 2 nests were found, but oftener the search was fruitless. For lack of time to devote exclusively to this purpose, the writer was forced to rely chiefly on a reliable collector who would make the daily search and bring the eggs to the Laboratory, with information as to depth, temperature, and location.

The notes that follow were almost all made during the summer of 1905; though a few records were made during previous seasons. Data for which the writer is not personally responsible are excluded, except where given with proper qualifications.

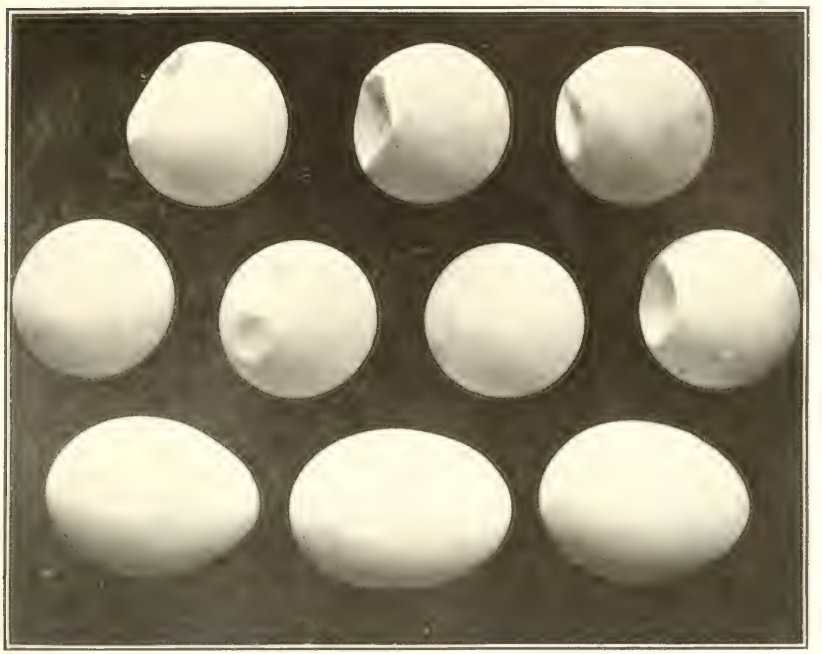
Laying Season.—In 1905 eggs were taken on the following dates: June 14th (2 nests), 15th, 19th, 27th, (2 nests), 29th, 30th, July 8th (2 nests), 10th (2 nests and signs observed of 2 others destroyed by hogs), 22d (2 nests), and 28th. On May 31st I was reliably informed of nests found during the preceding week, May 21-27, and, later, of a nest dug about June 5th; but collecting trips on the 6th and 10th were fruitless. In 1903 nests were reported a few days before and after June 14th, and I dug one on July 9th. In 1904 nests were reported July 24th and on August 5th eggs were brought by a fisherman, who reported the finding of 4 nests, two of which had been destroyed by hogs. The laying season near Beaufort probably begins in May and may extend into August, but is chiefly June and July.

Number of Eggs.—In 7 nests the following number of eggs were counted respectively: 118, 123, 128, 143, 146, 152. Various other numbers were reported by a fisherman who brought eggs to the Laboratory. In one case he brought 42 eggs, and reported 60 as the number found in the nest.

Form of Nests.—The top eggs were about 13 inches below the surface (12, 12, 12½, 13, 13 and 15 inches being the actual measurements in 6 nests). The mass of eggs, being from 8 to 12 or more inches deep, the lowest eggs were from 20 to 26 inches below the surface. In one instance the eggs were removed without destroying the shape of the hole. The space occupied by the eggs was sub-spherical with flat top, and was 10 inches in diameter by 8 inches deep. This nest contained only 123 eggs.

The changes of temperature at such a depth during the course of the day were not followed, but, when the nests were taken—time of day varying from 6 to 11 A. M.—the temperatures noted showed little differences, varying from 26½° to 28° C. Sand taken from the side of one nest was found to contain 3.8 per cent of water.

Location of Nests.—In the cases of about 8 nests observed by the writer, and in every other case, so far as known, the nests were located either just below or just on the foot of the slopes of the steep sand-dunes that line the beach on Bogue Banks. Hence the distance of nests from the water varied considerably. The elevation of the nests above the water-level also varied considerably. Without means of making accurate observations from a fixed bench-mark, a spirit level and vertical rod were used to measure the approximate elevations of



A. FRESHLY LAID EGGS OF LOGGERHEAD SEA-TURTLE. THE THREE LOWER ONES ARE CHICKEN EGGS.

B. EGGS OF LOGGERHEAD SEA-TURTLE AFTER INCUBATION FOR A PERIOD IN AN ARTIFICIAL NEST.

these nests. For 3 elevations taken the same day, a distinct line on the beach made by a recent very high tide was used as a base. The elevation of the surface of the ground at the nest, above the base line, was found to be in one case 4.75 feet, in a second 5.7 feet, and in a third 6.3 feet. The lowest eggs in these nests would thus be from 2.75 to 4.3 feet, roughly, above the level of a very high tide. The surface of the ground at another nest was washed by a very high tide, while I was present; yet the eggs from this nest, marked and left, hatched very successfully. The base of the sand-dunes, and not the distance above water, seemed to be the chief factor in determining the location of the nest. Almost all of the nests were made, however, in regions where this location would be not very distant from the edge of the water.

The nests were found along the beach from the region of Hoop Hole Camp (5 miles west of Fort Macon) to about 4 miles west of the "Old Steamer" (a local landmark formed by a wreck situated about 10 miles west of Fort Macon). The search was not continued farther west.

Thus, the conditions at the various nests were rather uniform as regards:

Location at foot of dunes.

Depth and form of nest.

Time of laying, in so far as all nests were probably made at night.

They were variable, however, in respect to:

Elevation above water-level.

Distance from water-line on beach.

Number of eggs laid.

Date of laying (May to August).

The Egg.—Pl. XX, A, shows the size and shape of these eggs as compared with the eggs of the common fowl. The shells are calcareous, but soft, and, as the contents do not completely fill the shell, there is always a dent in the egg. Often in course of the development of transplanted eggs, after the formation of the embryonic membranes, water is taken in through the shell, completely filling it out, so that the egg becomes spherical. The shell may thus become tightly distended and much enlarged; if many eggs in a nest become so distended, great inter-pressure results and the eggs become distorted in shape (Pl. XX, B).

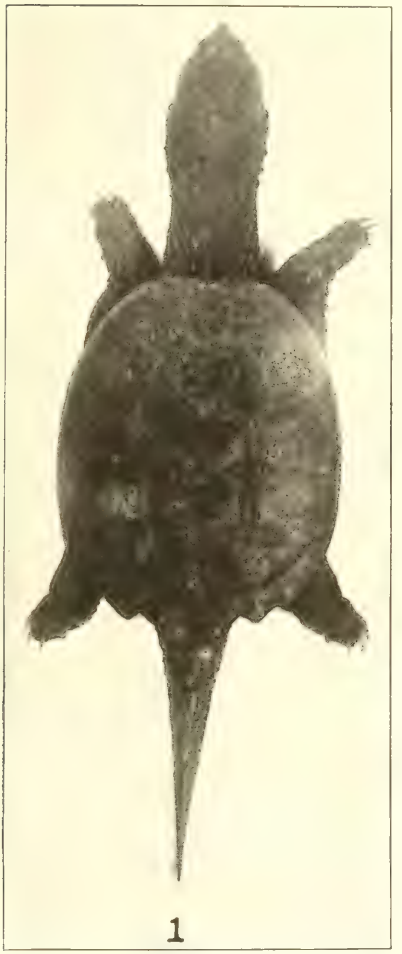
Incubation.— Many of the eggs obtained were replanted on the island, and, while it is not the purpose to give in this place the details regarding the incubation experiments, it may be said that the transplanting of the eggs seemed in every case detrimental. The transplanted eggs, though handled with much care, usually went bad, only a small per cent developing. Somewhat better success was obtained from the use of an extemporized "incubator" (a double box with six inches of sand between the walls all around), in which the temperature and moisture conditions could be kept fairly uniform (26°-28 1-3° C.=79°-83° F.). On one occasion the temperature went as low as 23 1-3° C., on another as high as 29° C.

The best per cent of development in any of the artificial nests was shown by a lot of 72 eggs in the incubator, from which at various times (12th to 31st day) 54 live embryos were obtained; thus 75 per cent of the eggs examined contained live embryos. From 51 eggs of the same original nest as the above lot, but replanted in the ground, 28 live embryos were obtained (12th to 16th days), or 55 per cent. The per cent of hatched turtles would probably have been less in each case. Only one nest was left as made by the turtle. In this case, the nest was protected by a sheet of wire netting, 30 inches square, placed in the sand about 3 inches above the eggs. Around the margin of the netting, strips of board extended 3 inches vertically below the wire. For greater security against destruction by hogs, 8 legs were driven into the sand and then nailed to the frame. This nest was examined on the 87th day; and only 2 unhatched eggs were found. Just beneath the wire were 29 live and 47 dead turtles, besides the mortified remains of a number of others. The percentage that hatched in this natural nest was, therefore, very high.

In the nests in the earth the exact date of hatching was not usually determined, for the turtles do not come to the surface immediately, and it was not desirable to disturb the nests often. Some hatched on the 73d day, others required a longer time. In the incubator, where development proceeded more slowly, the first turtle was observed hatching on the 83d day, others were out by the 88th, and two were later.

The young did not live long in aquaria (5 to 45 days), and while kept, they ate small bits of oysters.

Pl. XIX, fig. 1, shows a loggerhead turtle taken in Pains Bay, Dare County (on the northwest side of Pamlico Sound). Specimens



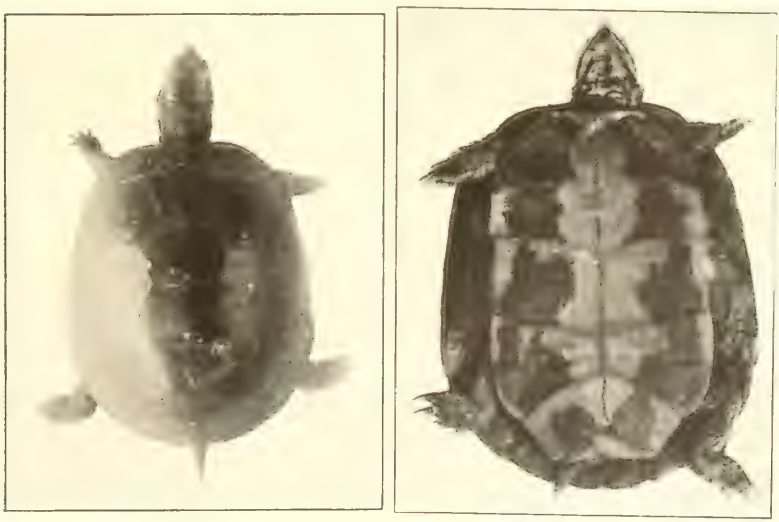
FIGS. 1 AND 2, COMMON SNAPPING-TURTLE, LOCAL SWAMP TURTLE.

FIG. 3, SIDE VIEW OF SAME.

A. COMMON MUD-TURTLE. KINOSTERNON PENNSYLVANICUM.

B. YELLOW-BELLIED TERRAPIN. PSEUDEMYS SCRIPTA SCHOPF.

A, GROUP OF BOX TURTLES, TERRAPENE CAROLINA.



B, SPECKLED TORTOISE, CLEMMYS GUTTATUS, SCHNEIDER.

found are usually covered with barnacles as in the photograph. A loggerhead kept for a while in an aquarium at the Laboratory ate heartily—blue crabs or "sand dollars" (*Mellita*). Embryo and newborn turtles are shown respectively in figs. 2 and 4 of Pl. XIX. The sharp point on the snout with which the turtle breaks through the shell may be seen in fig. 3 of Pl. XIX; the head at the left is that of an embryo (63d day), on which the beak has not yet become sharp.

It is intended to submit at another time further details regarding incubation and development.

LAND AND FRESH-WATER TURTLES.

While special effort was not made to collect the land and fresh-water turtles, a note may be added as to the species that came under observation.

Common Snapping-Turtle.—Of the *Chelydridæ*, the common snapping-turtle, *Chelydra serpentina* (L.), is the common "swamp-turtle" of the fresh-water ponds. A number of specimens were sent to the Laboratory from Wit, a point on Core Sound. This species has a market value, though perhaps not sufficient to justify its being shipped to market from a considerable distance. The specimen represented in figs. 1, 2, and 3, Pl. XXI, measured 7.7 inches, length of carapace.

Common Mud-Turtle.—The *Kinosternidæ* are represented by the common mud-turtle, *Kinosternon pennsylvanicum* (Bose), abundant in ditches and muddy streams about Beaufort. It is interesting that this turtle was found to be common on the brackish marshes about Pamlico Sound, at least near Pains Bay. A of Pl. XXII shows the ventral sides of 2 specimens.

Of the *Emydidæ* there are at least three representatives, besides *Malaclemmys centrata*. One specimen of *Pseudemys scripta* Schöpf, the "yellow-bellied terrapin," was brought to the Laboratory from the back country near Beaufort, the locality of capture unknown. The 2 figs. B, Pl. XXII, show, respectively, the dorsal and ventral aspects of the shell. *Clemmys guttatus* (Schn.), the speckled tortoise, or "lady terrapin" (Pl. XXIII, B), is very common. *Terrapene carolina* (L.), the common box-turtle (Pl. XXIII, A), is found in the woods.

The *Trionychidæ* and the *Testudinidæ* seem to be the only American families not represented at Beaufort, and there may be some doubt in regard to the *Trionychidæ*. Of those represented, all except the *Dermochelydidæ* (specimens of which are rare at any point on our coast) have representatives that are common.

OTHER TURTLES REPORTED FROM EASTERN NORTH CAROLINA.

In this connection, reference may be made to two other turtles sometimes supposed to occur about Beaufort. For the distribution of *Eretmochelys imbricata* (L.), the true "hawksbill" or tortoise-shell turtle, Jordan gives "North Carolina to Brazil." Perhaps this is based in part on True's statement on page 150 of "Aquatic Reptiles and Batrachians of the United States" (1893), that this turtle "is occasionally brought to our markets from North Carolina." The account of the distribution of this turtle given by True on the preceding page (p. 149) seems to imply that the southern coast of Florida is the northern region of its distribution. Holbrook, quoted by True, records the finding of a single specimen on the coast of Carolina (presumably South Carolina). His words are: "found only at the extreme southern points of the United States; once only I knew a fine specimen driven to the shores of Carolina during an equinoctial storm." I am indebted to Dr. Stejneger, of the U. S. National Museum, for the following statements: "I can find no definite reference to a specimen of *Eretmochelys imbricata* from North Carolina. * * * In the manuscript cards giving distribution of this species, there is no reference to North Carolina"; and to Mr. H. H. Brimley, of the State Museum at Raleigh, N. C., for the information that he has not been able to obtain a specimen or to learn of its occurrence in North Carolina. In the absence of any authentic record, therefore, this State should not be included within the range of distribution of *Eretmochelys*. The error in previous statements has, doubtless, arisen from the unfortunate application in North Carolina of the name "hawksbill" to Kemp's Gulf turtle.

The other species referred to is *Aspidonectes ferox* Schw. (one of the soft-shelled turtles) which Coues and Yarrow (1878) note as "tolerably common in fresh-water streams of mainland." This turtle does not seem to be known to inhabitants of Beaufort, whose attention it would undoubtedly have attracted if it were "common." The fact that Beaufort is so far east of the regions this turtle is known to

inhabit suggests that in some way a mistake occurred. But the river swamps of eastern Carolina (north and south) have been little explored from a zoölogical standpoint; and my brother has informed me of the finding of soft-shelled turtles in the Peedee River swamp near Society Hill, South Carolina, the peculiarity of which attracted much local attention. Mr. Brimley writes: "We have a specimen in the Museum caught in Neuse River, this county (Wake); but as two were turned into a pond from which the stream runs into Neuse River and not long afterwards the dam broke, and this capture was subsequent to the breaking of the dam, it is perhaps too much to regard the soft-shelled turtle as an inhabitant of these waters on this evidence." Hence Coues and Yarrow may well have observed these turtles near Beaufort, and been led to suppose that they were common inhabitants of the region.

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THE NORTH CAROLINA GEOLOGICAL SURVEY

JOSEPH HYDE PRATT, STATE GEOLOGIST.

BULLETIN No. 14

THE CULTIVATION OF THE DIAMOND-BACK TERRAPIN

BY

R. E. COKER, PH. D.

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